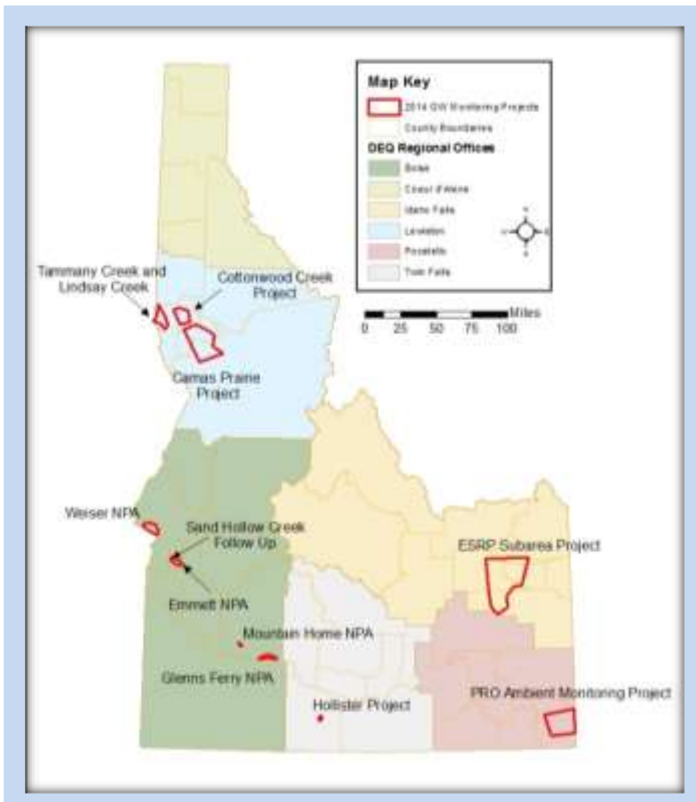
Summary Report for the Idaho Department of Environmental Quality Ground Water Quality Monitoring Projects—2014

Ground Water Quality Technical Report No. 48



State of Idaho
Department of Environmental Quality

March 2016

Printed on recycled paper, DEQ, March 2016,
PID 9010, CA 82017. Costs associated with this
publication are available from the State of Idaho
Department of Environmental Quality in accordance
with Section 60-202, Idaho Code.

Summary Report for the Idaho Department of Environmental Quality Ground Water Quality Monitoring Projects—2014

March 2016

Prepared by
Idaho Department of Environmental Quality
Water Quality Division
1410 N. Hilton
Boise, Idaho 83706

Acknowledgments

Compiled and edited by Kathryn Elliott.

Thank you to the following people, all of the Idaho Department of Environmental Quality, who assisted with various sections of this annual report:

- Rebecca Goehring authored the Boise region project summaries (section 2.1).
- Flint Hall, PG, authored the Idaho Falls region project summary (section 2.2).
- Paul Patchin, PG, Brady Johnson and Susan Beattie, PG, authored the Lewiston region project summaries (sections 2.4).
- David Goings authored the Pocatello region project summary (section 2.5).
- Irene Nautch authored the Twin Falls region project summary (section 2.6).
- Joanna Hahn created the map (Figure 1) of the 2014 ground water quality project locations by region and all figures in Appendix B.

Also, thank you to the following Idaho Department of Environmental Quality staff who provided technical and editorial review that improved the quality of this report: Edward Hagan, Erica Shiflet, and Jill White.

Table of Contents

List of Tables

List of Figures

Acronyms, Abbreviations, and Symbols

°C	degrees Celsius
µg	micrograms
µS	microsiemens
bgs	below ground surface
BMP	best management practice
BPA	bisphenol A
BTEX	benzene, toluene, ethylbenzene, and xylene
$CaCO_3$	calcium carbonate
CCL-4	Contaminant Candidate List - 4
cfu	colony-forming unit
cm	centimeter
DEQ	Idaho Department of Environmental Quality
DO	dissolved oxygen
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
FSP	field sampling plan
GPS	Global Positioning System
IBL	Idaho Bureau of Laboratories
IDAPA	refers to citations of Idaho’s administrative rules
IDWR	Idaho Department of Water Resources
ISDA	Idaho State Department of Agriculture
L	liter
m+p-xylene	meta-xylene plus para-xylene
MCL	maximum contaminant level
mg	milligrams

mL	milliliter
MPN	most probable number
NA	not applicable
NAU CPSIL	Northern Arizona University–Colorado Plateau Stable Isotope Laboratory
ND	nondetect
NPA	nitrate priority area
NS	not sampled
NSDWR	National Secondary Drinking Water Regulation
NTU	nephelometric turbidity unit
o-xylene	orthoxylene
per mil (‰)	parts per thousand
PWS	public water system
QAPP	quality assurance project plan
RD	rejected data
RSIL	Reston Stable Isotope Laboratory
SMCL	secondary maximum contaminant level
TDS	total dissolved solids
TMDL	total maximum daily load
TPH	total petroleum hydrocarbons
UIASL	University of Idaho Analytical Sciences Laboratory
USGS	US Geological Survey
VSMOW	Vienna Standard Mean Ocean Water
$\delta^{15}N$	ratio of the two stable nitrogen isotopes ^{15}N and ^{14}N
$\delta^{15}N_{nitrate}$	ratio of the two stable nitrogen isotopes ^{15}N and ^{14}N of the nitrate molecule
$\delta^{18}O$	ratio of the two stable oxygen isotopes ^{18}O and ^{16}O
$\delta^{18}O_{nitrate}$	ratio of the two stable oxygen isotopes ^{18}O and ^{16}O of the nitrate

molecule

δ^2H ratio of the two stable hydrogen isotopes ^1H and ^2H (deuterium), also denoted as δD

1 Introduction

Ground water is a key resource in Idaho—providing drinking water to 95% of Idahoans—and a critical component of the state's economy. The economic and social vitality of every Idaho community depends on access to a safe and clean ground water supply.

Idaho Code §39-120, "Environmental Quality - Health," designates the Idaho Department of Environmental Quality (DEQ) as the primary agency to coordinate and administer ground water quality protection programs for the state. DEQ is also responsible for collecting and analyzing data for ground water quality management purposes. Idaho Code §39-120 further directs DEQ, the Idaho Department of Water Resources (IDWR), and the Idaho State Department of Agriculture (ISDA) to conduct ground water quality monitoring and promote public awareness of ground water issues by making results of ground water quality investigations available to the public.

Public water systems (PWSs) are regulated by DEQ under the federal Safe Drinking Water Act and the "Idaho Rules for Public Drinking Water Systems" (IDAPA 58.01.08). These regulations require chemical analysis of drinking water for various contaminants. DEQ ensures that follow-up monitoring is conducted when contaminants of concern are detected in PWSs. The United States Environmental Protection Agency (EPA) has set National Primary Drinking Water Regulation standards, expressed as maximum contaminant levels (MCLs), that are legally enforceable standards that apply to PWSs. These levels are set to protect public health by limiting the amount of contaminants in drinking water. EPA has also set National Secondary Drinking Water Regulations (NSDWRs), expressed as secondary maximum contaminant levels (SMCLs), which are nonmandatory standards that are established as guidelines to assist PWSs in managing their drinking water for aesthetic considerations such as taste, color, and odor.

Although these limits only apply to PWSs, they can be used to evaluate water quality in private wells, as is done throughout this report. Total coliform and *Escherichia coli* (*E. coli*) sampling results were compared to the Idaho Ground Water Quality Standards set forth in Idaho's Ground Water Quality Rule (IDAPA 58.01.11), rather than national regulations. The single samples collected during these projects were not appropriate for comparison to the national standards, which are based on exceedances during a month-long sampling period.

DEQ also responds to detections of contaminants of concern that are found by monitoring programs implemented by other entities, such as the Statewide Ambient Ground Water Quality Monitoring Program, administered by IDWR. Follow-up investigations may develop into a DEQ local or regional monitoring project to assess conditions and identify areas where public health may be threatened. The investigation results can facilitate management decisions that protect the resource and promote public awareness for ground water protection.

Field measurements taken during follow-up investigations and monitoring projects should be considered estimates and are not used for determining SMCL exceedances at PWS wells. They are used to monitor well water during purging to ensure water in the wellbore is removed from the well prior to sampling. Field measurements are also used to qualitatively evaluate water quality variability between wells.

The ground water quality monitoring results can also be used to define and prioritize degraded ground water quality areas, such as nitrate priority areas (NPAs). In 2014, DEQ identified 34 areas in the state as having elevated concentrations of nitrate in ground water. These NPAs are ranked based on population, water quality, and water quality trends. The basis for an NPA is that 25% or more of the wells sampled within the designated area have nitrate concentrations that meet or exceed 5 milligrams per liter (mg/L). EPA has established an MCL for nitrate at 10 mg/L, and Idaho adopted this MCL as the Ground Water Quality Standards. The NPAs are reevaluated and re-ranked approximately every 5 years. Additional information about NPA delineation and ranking is available from the *2014 Nitrate Priority Area Delineation and Ranking Process* document (DEQ 2014a).

Prioritization is necessary to effectively allocate resources for water quality improvement strategies. DEQ has worked in coordination with state and federal agencies, as well as stakeholders, to develop ground water quality improvement plans, also known as ground water quality management plans, that address ground water degradation in NPAs. Ground water quality data are used to evaluate the effectiveness of plan implementation.

The Ground Water Program at DEQ has implemented regional ground water monitoring using a statistically based approach to determine the monitoring network design. These regional projects have focused in areas designated as NPAs. This report provides an overview of DEQ's ground water monitoring projects and investigation activities accomplished with public funds during 2014. It does not include results from privately funded activities, including monitoring required by permits and monitoring associated with ongoing environmental remediation projects, Kootenai County Aquifer Protection District funding, or PWS requirements.

2 Summary of Ground Water Quality Projects by Region

This section presents data from ground water quality monitoring and investigation projects that were conducted by DEQ in calendar year 2014. Projects are presented by DEQ regional office and identified in Figure 1.

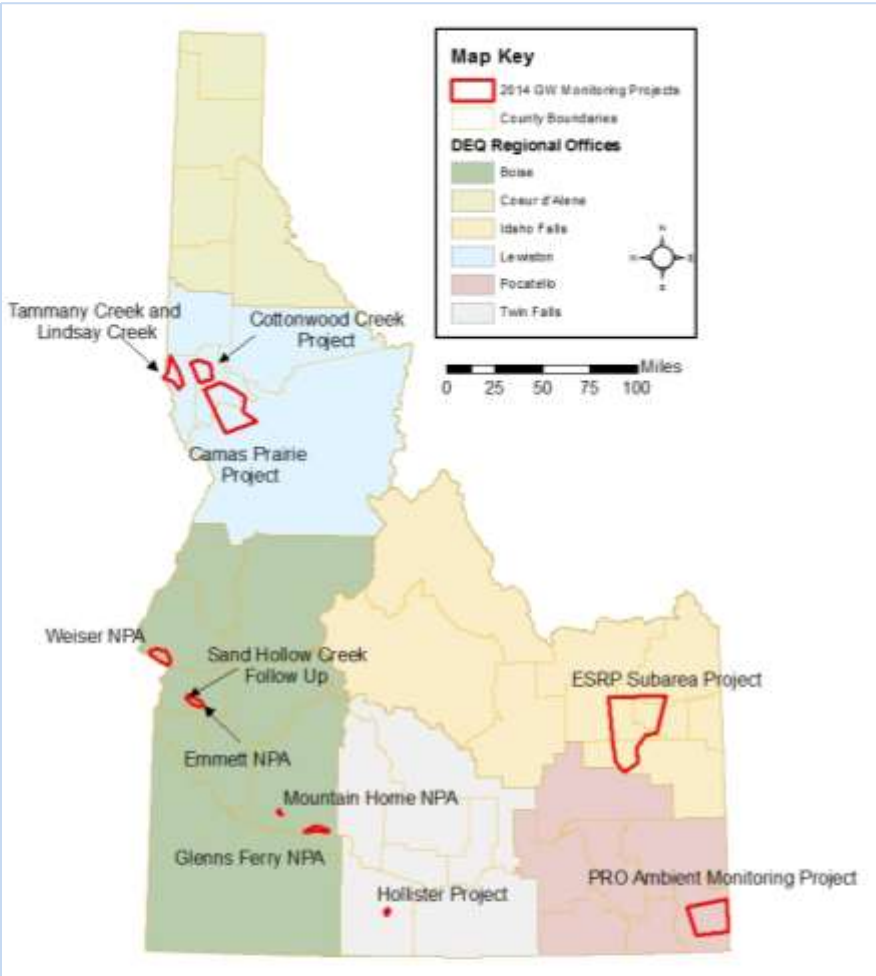


Figure 1. Idaho Department of Environmental Quality 2014 ground water quality project locations by region.

All ground water quality data contained in this section are available through an *interactive mapping application* available on DEQ's website. The application contains ground water quality data that DEQ or its contractors have collected from 1987 to the present. The application can be used to view and download data collected for over 350 contaminants, ranging from nitrate—a widespread ground water contaminant—to emerging contaminants such as personal care products and pharmaceuticals. The application was developed to help citizens, local officials, researchers, water quality professionals, consultants, and other stakeholders make informed decisions about land-use activities. The application also provides private well owners with an indication of ground water quality conditions in an area when considering treatment options for protecting their family's health.

2.1 Boise Region

Five ground water quality monitoring projects were conducted in the Boise region in 2014 using public funds.

2.1.1 Emmett North Bench Nitrate Priority Area Ground Water Monitoring Project

2.1.1.1 Purpose and Background

In 2008, the Emmett North Bench (ENB) NPA ranked as the 29th most impacted NPA in Idaho. In 2014, DEQ reevaluated all NPAs using the most recent data available. The ENB NPA ranking went from 29th to 33rd, and no observable trend was found in the trend analysis (DEQ 2014a). This ground water monitoring project was designed to continue gathering data necessary for evaluating the water quality and nitrate concentrations in the ENB NPA in Gem County. The predominant land use in the ENB NPA is agricultural and residential. All of the residences in the NPA are served by private wells.

The south and southwestern areas of Gem County, which include the ENB NPA, are located within the western Snake River Plain. The western Snake River Plain is a deep structural depression (basin) bounded by major northwest-trending faults (Newton 1991). A major lake system named Lake Idaho developed in the basin and existed from about 9.5 to 1.7 million years ago (Wood and Clemens 2002). Volcanic ash and lake and stream sediments, including clay, silt, sand, and gravel, were deposited in the basin (Newton 1991).

DEQ's review of the IDWR well driller's reports for wells located within the project area indicated the subsurface consists of interbedded clay, sand, and gravel. Project wells were generally completed in sand and gravel aquifers at depths ranging from 33 to 188 feet deep. The depth to ground water shown on well driller's reports for the project wells ranged from 15 to 113 feet below ground surface. A blue/gray clay layer was identified in approximately one-half of the well driller's reports. This clay, locally identified by well drillers as "blue clay," is often present in various thicknesses and elevations throughout the central and western Boise River valley. The clay forms confining units that can separate shallow aquifers from deeper zones (Petrich and Urban 2004). Based on IDWR's regional ground water flow map (IDWR 2014), the ground water flow direction within the ENB NPA is generally southwest towards the Payette River (Figure 2).

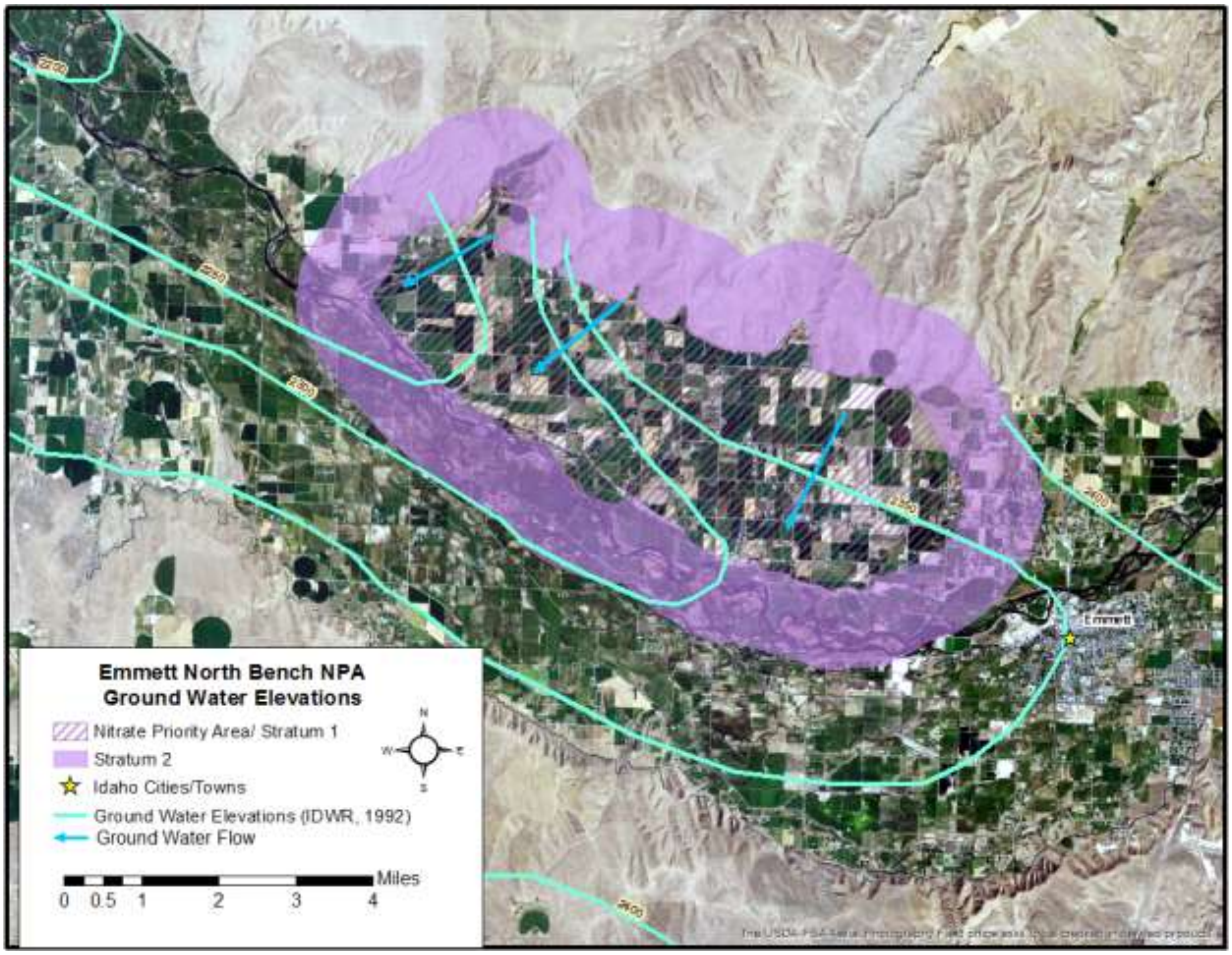


Figure 2. Ground water elevation contours—Emmett North Bench Nitrate Priority Area Ground Water Monitoring Project.

In 2014, DEQ collected ground water samples from 44 domestic and irrigation wells in the ENB NPA using procedures outlined in the *Regional Nitrate Priority Area Ground Water Monitoring Activities, Boise Region Quality Assurance Project Plan* (QAPP) (DEQ 2014i) and *Emmett North Bench Nitrate Priority Area Regional Ground Water Monitoring Network, Emmett, ID Field Sampling Plan* (FSP) (DEQ 2014c). Program objectives, design, and well selection processes are identified in the regional ground water monitoring network design (DEQ 2011a). DEQ analyzed the ground water samples for common water quality analytes, including nitrate and total coliform, to assess the water quality in the project area.

2.1.1.2 Methods and Results

A statistical process, developed for DEQ by Dr. Kirk Steinhorst of the University of Idaho, was used to determine the number of samples to be collected within the ENB NPA (Stratum 1) and outside the ENB NPA (Stratum 2, which surrounds Stratum 1 as a 1-mile buffer) to ensure the sampling event was statistically valid (Figure 2) (Steinhorst 2011). The statistical model determined that 46 wells located in Stratum 1 and 53 wells in Stratum 2 would need to be sampled to meet a 90% confidence level that the estimated mean is within 15% of the true mean. The model also determined the size of each sampling unit would be one quarter section. Site selection was coordinated with IDWR and ISDA in an effort to avoid duplication of sampling locations between agencies.

Stratum 1 did not contain enough quarter sections with wells to meet the number of wells required for statistical validity; therefore, each Stratum 1 well that met criteria was sampled. For this study, 31 wells were selected for sampling within the NPA Stratum 1.

The portion of Stratum 2 that can be sampled is very limited. The majority of the southern portion of Stratum 2 is south of the Payette River and outside the scope of the project. The majority of the northern portion of Stratum 2 covers an area in the foothills with no wells. To address the limited availability of wells in Stratum 2 and prevent clustering of wells, one sample was taken from each quarter section containing a well that met design criteria. A total of 13 wells were selected for sampling within Stratum 2.

Samples were collected in May 2014 from 44 wells in accordance with DEQ's *Regional Nitrate Priority Area Ground Water Monitoring Activities Boise Region* (QAPP) (DEQ 2014i) and the *Emmett North Bench Nitrate Priority Area Regional Ground Water Monitoring Network FSP* (DEQ 2014c). Water quality field parameters (i.e., pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 1).

Table 1. Water quality field parameters—Emmett North Bench Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Field Measurements			
			Water Temperature (°C)	pH[a]	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
1262	188	5/7/2014	17.4	7.87	390	0.1
1266	96	5/7/2014	14.4	7.58	364	0.8
1268	106	5/5/2014	14.9	7.8	415	0.62
1288	105	5/7/2014	14.8	*8.53*	319	0.01
1289	55	5/6/2014	14.3	7.74	626	9.95
1290	95	5/6/2014	15.1	8.27	528	0.06
1291	100	5/6/2014	14.2	7.38	445	0.02
1293	106	5/6/2014	14.9	7.57	471	2.9
1295	68	5/6/2014	14.1	7.48	784	7.93
		9/17/2014[b]	15.1	7.27	721	—
1296	43	5/6/2014	14.1	7.48	436	8.99
2231	113	5/6/2014	13.9	8.05	368	0
2233	109	5/7/2014	17.4	7.77	337	10.19
2306	121	5/5/2014	15.1	7.38	533	5.26
2309	60	5/7/2014	14.9	7.67	336	9.75
2310	68	5/6/2014	13.7	7.46	510	6.56
2311	85	5/7/2014	16.8	7.75	289	10.31
2312	80	5/6/2014	14.1	7.52	472	9.16
2313	79	5/7/2014	16	7.8	311	9.13
2314	85	5/7/2014	14.3	7.64	483	8.84
2315	65	5/6/2014	15	7.5	333	9.02
2316	130	5/5/2014	14.6	7.44	400	4.76
2317	129	5/5/2014	14.6	7.54	563	7.76
2318	98	5/5/2014	14.3	7.42	390	0.12
2319	115	5/6/2014	15.4	8.16	452	0
2321	117	5/5/2014	14.5	7.14	386	8.65
2323	73	5/5/2014	14.7	7.66	367	8.72
2324	54	5/6/2014	13.4	7.17	364	8.06
2325	44	5/6/2014	14.1	7.61	485	9.55
2326	33	5/6/2014	13.7	7.6	438	9.32
2327	92	5/7/2014	15.7	7.81	302	5.82
2328	84	5/6/2014	16	7.7	416	10.24
2329	103	5/6/2014	15.3	7.41	404	0.18
2330	83	5/7/2014	14.3	7.74	460	0.23
2331	86	5/7/2014	16.8	7.58	335	10.63
2332	117	5/5/2014	14.5	6.6	252	0.02

DEQ Site ID	Well Depth (feet)	Sample Date	Field Measurements			
			Water Temperature (°C)	pH[a]	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
2333	87	5/7/2014	15	7.91	346	0.74
2335	123	5/5/2014	14.9	7.51	249	9.15
2336	74	5/5/2014	16.5	7.78	279	6.96
2337	87	5/5/2014	15.5	7.43	298	9.19
2338	128	5/5/2014	14.8	7.32	274	7.92
2339	110	5/5/2014	15.2	7.86	466	7.83
2340	100	5/5/2014	14.2	7.78	665	8.88
2341	113	5/5/2014	15	6.95	423	6.59
2342	88	5/5/2014	14.6	7.35	331	8.79

Notes: (—) = data are unavailable or were not analyzed.
[a] Contaminant with a National Secondary Drinking Water Regulation standard. Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality. The NSDWR for pH is 6.5-8.5.
[b] Sample collected on 9/17/2014 was not analyzed for nitrate or the N^{15} isotope.

Samples collected from each well were analyzed for nitrate, nitrite, total coliform, and *E. coli* (Table 2). Nitrogen isotope samples were collected at each sampling location and frozen and stored at DEQ pending nitrate analysis. After DEQ received nitrate analysis results, those nitrogen isotope samples from wells with nitrate concentrations greater than 5 mg/L were sent to the University of Arizona Environmental Isotope Geosciences Laboratory in Tucson, Arizona, for nitrogen isotope analysis. A total of four wells (1289, 2321, 2328, and 1295) had samples with nitrate concentrations greater than 5 mg/L (Figure 3). Samples from these four wells were submitted for nitrogen isotope analysis (Table 2).

Table 2. Inorganic and bacteria results—Emmett North Bench Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Nutrient Concentrations			Bacteria[b]	
			Nitrate[a]	Nitrite[a]	$\delta^{15}N$	Total Coliform	*E. coli*
			(mg/L)		(‰)	(MPN/100 mL)	
Primary or Secondary Standard:			***10***	***1***	***NA***	***1 cfu/100 mL***	***<1 cfu/100 mL***
1262	188.6	5/7/2014	<0.18	<0.30	—	<1	<1
1266	96	5/7/2014	1.02	<0.30	—	<1	<1
1268	106	5/5/2014	<0.18	<0.30	—	<1	<1
1288	105	5/7/2014	<0.18	<0.30	—	<1	<1
1289	55	5/6/2014	6.24	<0.30	6.8	<1	<1
1290	95	5/6/2014	<0.18	<0.30	—	<1	<1
1291	100	5/6/2014	<0.18	<0.30	—	<1	<1
1293	106	5/6/2014	<0.18	<0.30	—	<1	<1
1295	68	5/6/2014	**13.6**	<0.30	9.7	<1	<1
1296	43	5/6/2014	4.76	<0.30	—	1.0	<1
2231	113	5/6/2014	<0.18	<0.30	—	<1	<1
2233	109	5/7/2014	2.88	<0.30	—	<1	<1
2306	121	5/5/2014	2.2	<0.30	—	<1	<1
2309	60	5/7/2014	3.24	<0.30	—	<1	<1
2310	68	5/6/2014	4.2	<0.30	—	<1	<1
2311	85	5/7/2014	2.66	<0.30	—	<1	<1
2312	80	5/6/2014	3.28	<0.30	—	<1	<1
2313	79	5/7/2014	2.84	<0.30	—	<1	<1
2314	85	5/7/2014	3.76	<0.30	—	<1	<1
2315	65	5/6/2014	2.26	<0.30	—	<1	<1
2316	130	5/5/2014	2.12	<0.30	—	<1	<1
2317	129	5/5/2014	0.617	<0.30	—	<1	<1
2318	98	5/5/2014	<0.18	<0.30	—	<1	<1
2319	115	5/6/2014	<0.18	<0.30	—	<1	<1
2321	117	5/5/2014	9.19	<0.30	4.4	<1	<1
2323	73	5/5/2014	3.23	<0.30	—	<1	<1
2324	54	5/6/2014	2.64	<0.30	—	<1	<1
2325	44	5/6/2014	2.42	<0.30	—	<1	<1
2326	33	5/6/2014	1.83	<0.30	—	<1	<1
2327	92	5/7/2014	1.76	<0.30	—	<1	<1
2328	84	5/6/2014	5.37	<0.30	0.5	<1	<1
2329	103	5/6/2014	0.353	<0.30	—	<1	<1
2330	83	5/7/2014	0.965	<0.30	—	<1	<1
2331	86	5/7/2014	3.48	<0.30	—	<1	<1
2332	117	5/5/2014	<0.18	<0.30	—	<1	<1
2333	87	5/7/2014	0.401	<0.30	—	<1	<1
2335	123	5/5/2014	1.65	<0.30	—	<1	<1
2336	74	5/5/2014	<0.18	<0.30	—	<1	<1
2337	87	5/5/2014	1.6	<0.30	—	<1	<1
2338	128	5/5/2014	1.8	<0.30	—	<1	<1

DEQ Site ID	Well Depth (feet)	Sample Date	Nutrient Concentrations			Bacteria[b]	
			Nitrate[a]	Nitrite[a]	$\delta^{15}N$	Total Coliform	*E. coli*
			(mg/L)		(‰)	(MPN/100 mL)	
Primary or Secondary Standard:			***10***	***1***	***NA***	***1 cfu/100 mL***	***<1 cfu/100 mL***
2339	110	5/5/2014	2.38	<0.30	—	<1	<1
2340	100	5/5/2014	3.25	<0.30	—	<1	<1
2341	113	5/5/2014	2.08	<0.30	—	<1	<1
2342	88	5/5/2014	0.952	<0.30	—	<1	<1

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. These regulations are applicable for public water systems only but are recommended limits and can be used to evaluate water quality in private wells. (—) = data are unavailable or were not analyzed.
[a] Contaminant with a National Primary Drinking Water Regulation standard.
[b] Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

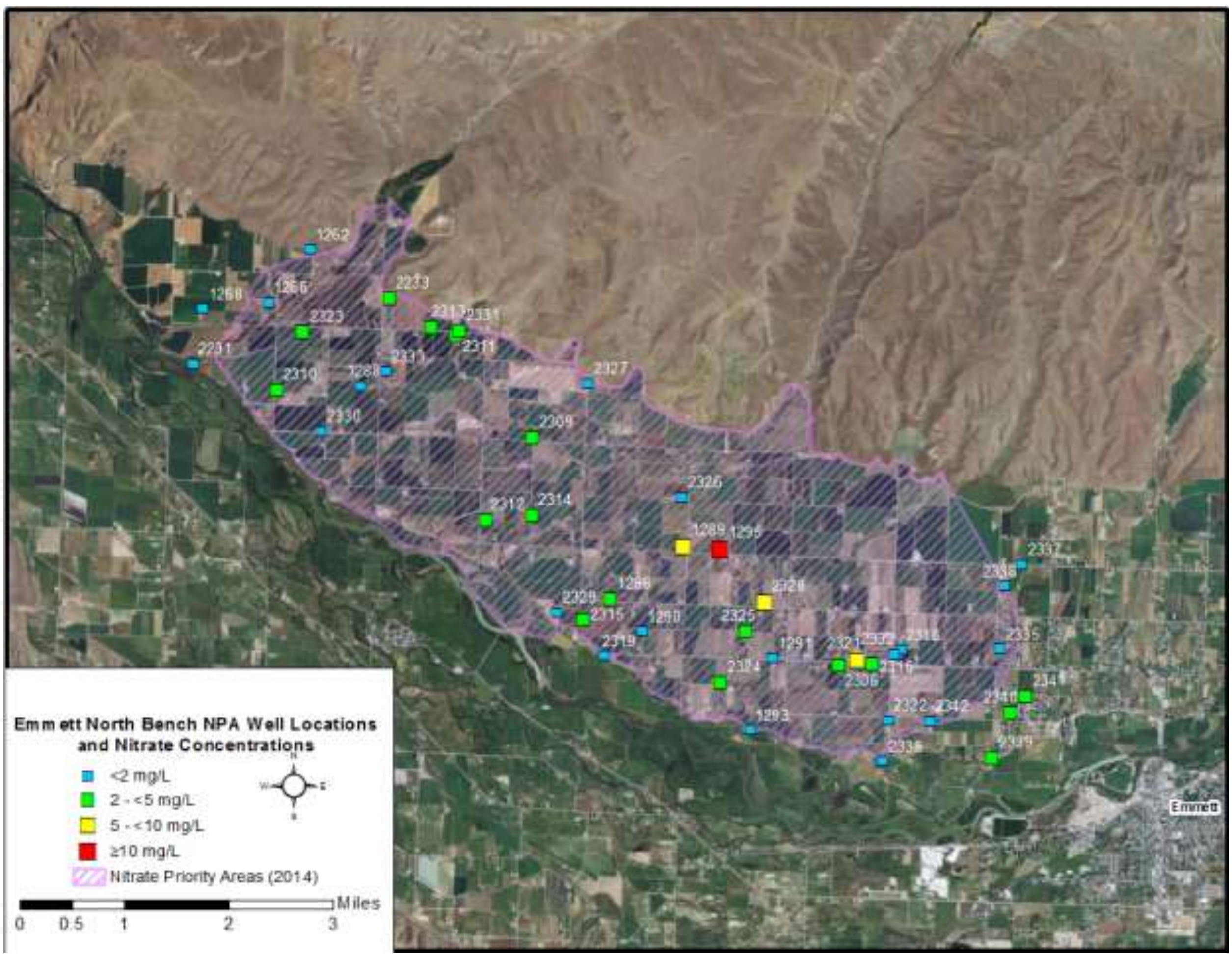


Figure 3. Sample locations and nitrate concentrations—Emmett North Bench Nitrate Priority Area Ground Water Monitoring Project.

Samples from Well 1295 were collected on May 6 and September 17, 2014 for immunoassay testing. The September sample was taken because there was available space in IBL's project and staff were in the area sampling another project. The two samples from Well 1295 were submitted to IBL for analysis of four selected immunoassay analytes: 17-beta estradiol, caffeine, sulfamethoxazole, and bisphenol A (BPA) (Table 3). The sample collected on 9/17/2014 was not analyzed for nitrate or the N^{15} isotope.

- 17-beta estradiol is a human sex hormone and steroid.
- Caffeine is a human organic waste indicator.
- Sulfamethoxazole is an antibiotic for human use. The FDA has prohibited the use of this antibiotic in animals used to produce milk or meat for human consumption.
- BPA is a chemical used in the production of plastic containers.

Table 3. Immunoassay results—Emmett North Bench NPA Ground Water Monitoring Project.

Site ID	Sample Date	17-Beta Estradiol (ng/L)	Caffeine (µg/L)	Sulfamethoxazole (µg/L)	Bisphenol A (BPA) (µg/L)
1295	05/06/2014	<2.5	<0.175	<0.025	0.15
1295	09/17/2014	<2.5	<0.175	<0.025	<0.05

Nitrate Results

The reported nitrate concentrations ranged from <0.18 mg/L to 13.6 mg/L; 4 of the 44 wells sampled (1289, 2321, 2328, and 1295) had nitrate concentration of 5 mg/L or greater (Table 2). The nitrate MCL of 10 mg/L was exceeded in one sample (1295). The spatial distribution of nitrate concentrations is shown in Figure 3.

Bacteria Results

The reported total coliform (TC) bacteria concentrations ranged from below the detection limit to 1 MPN/100 mL; 1 of the 44 wells sampled was positive for TC (1296) (Table 2). All 44 samples were negative for *E. coli*.

Nitrogen Isotope Results

Nitrogen isotope ratios, denoted as $\delta^{15}N$, can be helpful in determining the potential sources of nitrate in the ground water. Nitrogen isotope ratios were determined for the four samples with nitrate concentrations greater than 5 mg/L (Table 2). Nitrogen from human or animal waste and fertilizer sources has distinguishable $\delta^{15}N$ signatures. Typical $\delta^{15}N$ values for various nitrogen sources are listed in Table 4.

Table 4. Typical $\delta^{15}N$ values from various nitrogen sources.

Potential Nitrate Source	$\delta^{15}N$ (‰)
Precipitation	−4
Commercial fertilizer	−4 to +4
Organic nitrogen in soil or mixed nitrogen source	+4 to +9
Animal or human waste	Greater than +9

Source: Seiler 1996

The $\delta^{15}N$ results from this project ranged from 0.5‰ to 9.7‰. One well (2328) had a $\delta^{15}N$ ratio of 0.5‰, indicating the source of nitrates in the ground water is most likely from commercial fertilizer (Seiler 1996). Two wells (1289 and 2321) had $\delta^{15}N$ ratios between 4‰ and 9‰, indicating the source of nitrates in the ground water is most likely from organic nitrogen in soil or a mixed nitrogen source (Seiler 1996). One well (1295) had a $\delta^{15}N$ ratio 9.7‰, indicating the source of nitrates in the ground water is most likely from animal or human waste (Seiler 1996).

Immunoassay Results

Samples were collected from Well 1295 on May 6 and September 17, 2014, for 17-beta estradiol, caffeine, sulfamethoxazole, and BPA testing through an immunoassay analysis. The reported results for all four constituents in the immunoassay test were below the laboratory detection limit with the exception of BPA (Table 3). BPA was detected in May at a concentration of 0.15 μg/mL. Currently these constituents are not subject to any proposed or promulgated national primary drinking water regulations. However, 17-beta estradiol, an estrogenic hormone and used in pharmaceuticals, is included in EPA's draft contaminant candidate list – 4 (CCL-4). Contaminants on the CCL are known to occur in public water systems and may require future regulation under the Safe Drinking Water Act (SDWA).

2.1.1.3 Conclusions

The criterion for an NPA is at least 25% of the wells sampled within the area meet or exceed 5 mg/L nitrate. This value is half of the MCL of 10 mg/L. In 2014, 4 of the 44 wells sampled for this project, approximately 9%, had nitrate values equal to or greater than 5 mg/L. The nitrate MCL of 10 mg/L was exceeded in one of these samples (well 1295). In the NPA (stratum 1), 4 of the 31 (13%) wells had nitrate concentrations greater than 5 mg/L. These wells were located in the center and southeastern portion of the ENB NPA. None of the 13 wells sampled outside the NPA had nitrate concentrations greater than 5 mg/L.

The $\delta^{15}N$ results in the NPA suggest a mixture of nitrate sources, including fertilizer and organic sources such as crop decay (e.g., legume crop plow down) and/or organic nitrogen in the soil.

The primary land uses in the ENB NPA are agricultural and residential. The agricultural use is a mixture of irrigated agriculture (cropland) and dairies.

2.1.1.4 Recommendations

DEQ recommends that property owners with private domestic drinking water wells sample their well—prior to any water treatment system and as close to the well as possible—on an annual basis. Southwest District Health can provide Gem County property owners with information and guidance regarding well sampling and interpretation of results.

In addition, property owners may benefit from education on the use of commercial fertilizers and pesticides on their lawns and gardens and education on proper maintenance of their wells and septic systems.

DEQ has assisted Gem County in developing and implementing a ground water quality improvement plan. This plan includes outreach activities for private well owners and agricultural operators aimed at reducing ground water contamination, including activities to reduce nitrate contamination.

The Gem Soil and Water Conservation District (SWCD) and the Natural Resources Conservation Service contracted with the owners of 360 acres of farmland to install BMPs to address natural resource concerns in 2013. A description of the 2013 SWCD projects can be found at *http://swc.idaho.gov/media/12278/Gem-SWCD-Performance-Report-2013.pdf*.

2.1.2 Sand Hollow Creek Follow-Up Ground Water Monitoring Project

2.1.2.1 Purpose and Background

In response to the sample results of the 2013 Sand Hollow Creek monitoring project, the purpose of this project was to collect additional samples from Well 2232 for nitrate and bacteria (total coliform and *E. coli*) analysis in an effort to determine if bacteria are present and whether trends in nitrate data exist.

The 2013 Sand Hollow Creek monitoring project was conducted in response to a complaint DEQ received on September 3, 2013, concerning possible bacteria and nitrate contamination of wells in the vicinity of a dairy operation (Sage Dairy) and a farming operation (Rim Fire Ranch). Both Sage Dairy and Rim Fire Ranch are located in the Sand Hollow Creek drainage within the 2008 ENB NPA (Figure 4). In response to the complaint in 2013, DEQ sampled ground water quality in eight wells (project wells) in the project area northwest of Emmett.

Samples from seven of the eight project wells sampled in 2013 contained nitrate concentrations below the nitrate MCL of 10 mg/L (some below detectable concentrations). The sample from Well 2232 exceeded the nitrate MCL with a concentration of 19.0 mg/L. DEQ submitted a sample from Well 2232 for nitrogen isotope analysis. The nitrogen isotope value was 9.1‰, suggesting that the nitrate in the ground water originated from animal or human waste (Table 4). Two of the eight project wells tested positive for total coliform; however, Well 2232 was not one of the two wells with a positive detection. No *E. coli* was detected during the 2013 monitoring efforts.

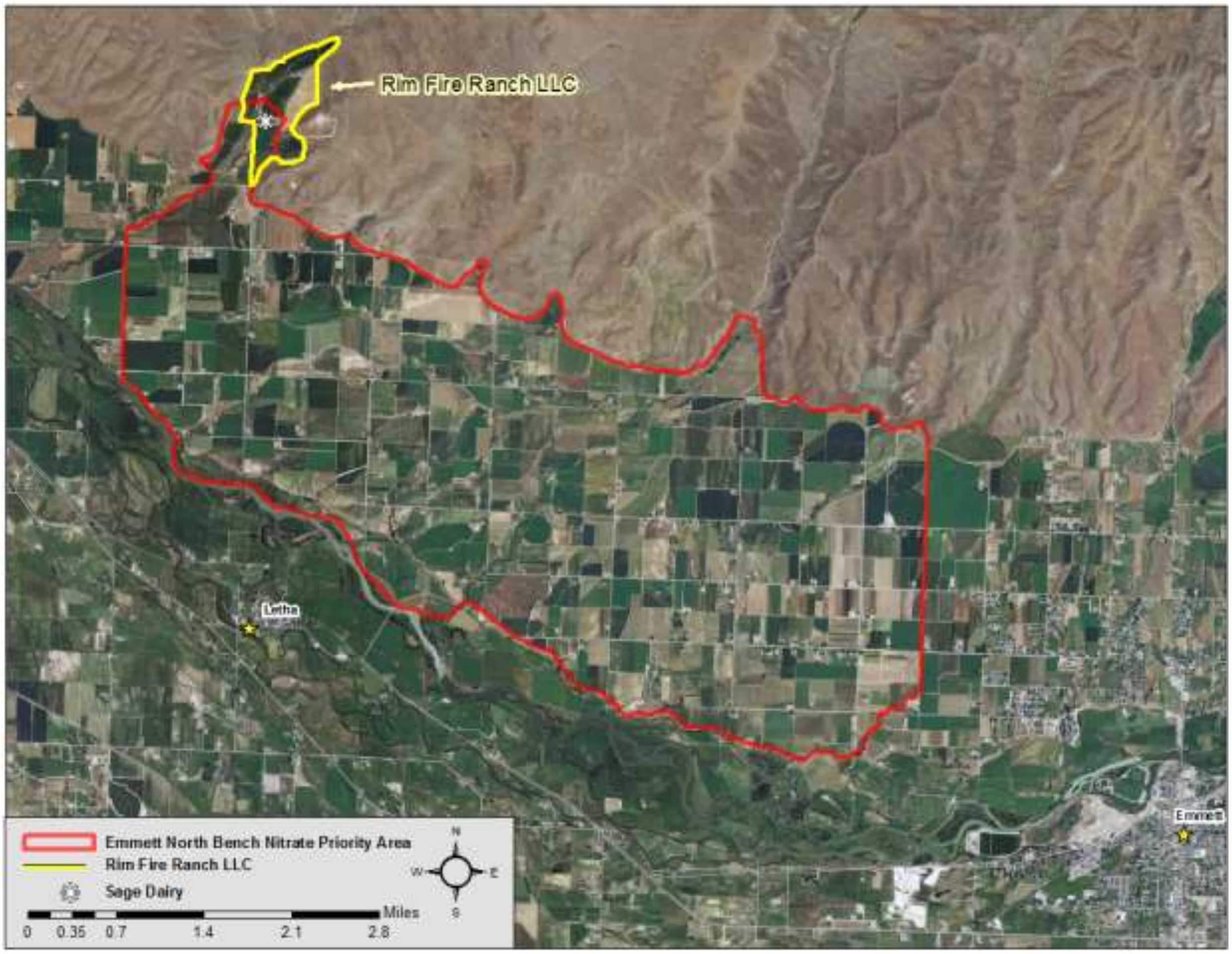


Figure 4. Location of Sage Dairy within the Emmett North Bench Nitrate Priority Area on the Rim Fire Ranch LLC property.

The ISDA Dairy Bureau collects ground water samples for nitrate analysis at dairy production wells during annual facility inspections. When a sample has a nitrate concentration that exceeds the MCL of 10 mg/L for nitrate, ISDA provides the information to DEQ. The ISDA Dairy Bureau samples from the Sage Dairy site production well show nitrate concentrations above the MCL since 2000. The ISDA data indicate a declining trend from 17.10 mg/L in 2000 to 11.60 mg/L in 2013. However, the nitrate concentration rose from 11.60 mg/L in 2013 to 13.10 mg/L in 2014 (Table 5, Figure 5).

ISDA also collects isotope samples every 5 years from dairy production wells with previous nitrate concentrations greater than 5 mg/L. Nitrogen isotope ratios ($\delta^{15}N$) can be helpful in determining sources of nitrate in the ground water, as nitrogen from human or animal waste and fertilizer sources has distinguishable $\delta^{15}N$ signatures. The ISDA samples collected for nitrogen isotope analysis in 2000, 2005, and 2010, all had $\delta^{15}N$ signatures above 9‰, indicating that animal or human waste is contributing nitrogen to the ground water supplying water to the dairy production well (Table 5).

Table 5. ISDA Dairy Bureau nitrate concentration and nitrogen isotope data—Sage Dairy site production well.

Sample Date	Nitrate Concentration (milligrams per liter)	$\delta^{15}N$ (‰)
05/15/2000	**17.10**	9.54
03/19/2002	**18.90**	NS
02/14/2003	**17.00**	NS
02/24/2004	**17.90**	NS
03/01/2005	**17.00**	NS
06/22/2005	NS	10.24
05/03/2007	**14.40**	NS
08/21/2008	**14.10**	NS
04/14/2009	**11.70**	NS
07/20/2010	**12.10**	NS
08/23/2010	NS	9.36
11/08/2012	**11.60**	NS
10/16/2013	**11.60**	NS
10/14/2014	**13.10**	NS

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. The MCL for nitrate is 10 milligrams per liter. NS = not sampled.

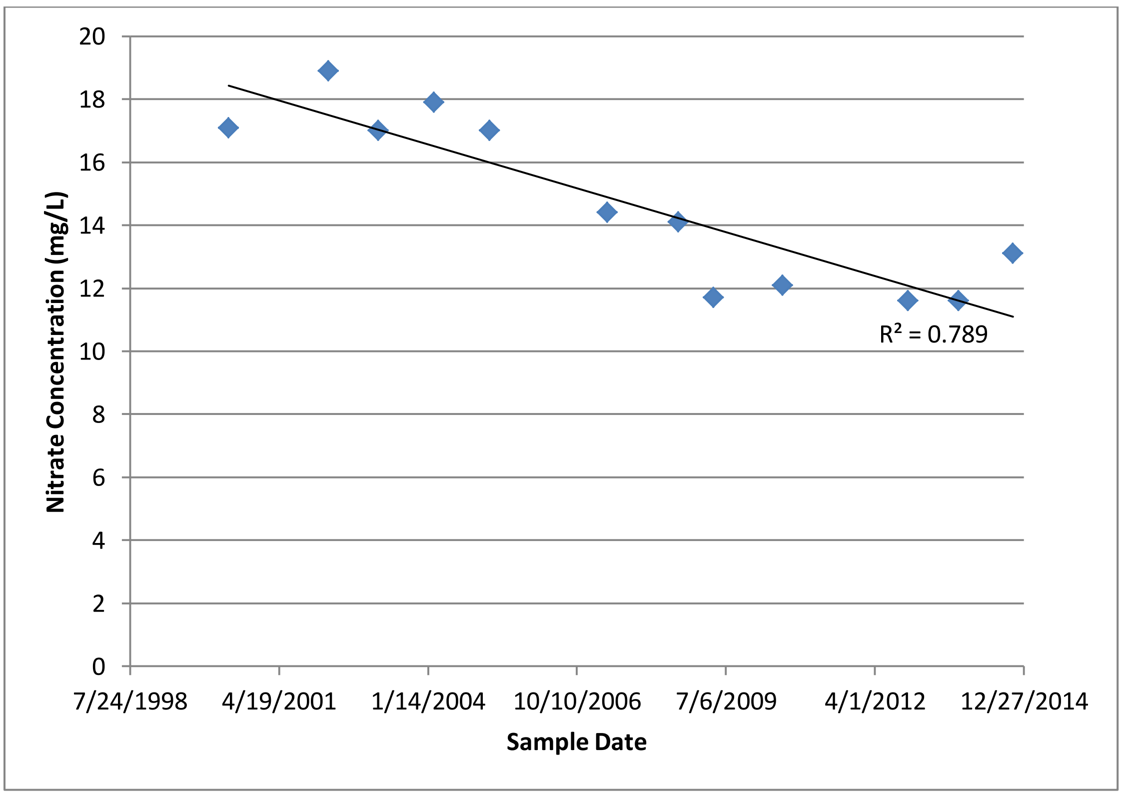


Figure 5. ISDA Dairy Bureau nitrate concentrations—Sage Dairy site production well.

Well driller's logs from wells located within and surrounding the project area indicate the lithology consists of interbedded clay, sand, and gravel. The depth to ground water shown on well driller's logs for private, domestic wells located to the south and southwest of Well 2232 ranges from approximately 70 to 110 feet below ground surface (bgs). Ground water occurs under both confined and unconfined conditions. Ground water is believed to flow in a southwesterly direction in the project area. Based on ground water flow information from IDWR, Well 2232 is located downgradient from the Rim Fire Ranch property and Sage Dairy (Figure 6).

Figure 6. Sample location—2014 Sand Hollow Creek Follow-Up Ground Water Monitoring Project.

2.1.2.2 Methods and Results

On May 21, 2014, DEQ sampled Well 2232 for nitrite, nitrate, nitrogen isotope, and bacteria (total coliform and *E. coli*). Follow up sampling was conducted on September 15, 2014, for nitrite, nitrate, and bacteria and September 17, 2014, for nitrogen isotope. Samples were collected on each sampling date in accordance with DEQ's *Local Dairy Nitrate Exceedance Follow-up Ground Water Monitoring* QAPP (DEQ 2012) and the *Sand Hollow Creek Complaint Follow-Up Ground Water Monitoring Project, Emmett, ID* field sampling plan (FSP) (DEQ 2014j). Water quality field parameters (pH, temperature, specific conductivity, and dissolved oxygen [DO]) were measured prior to sample collection (Table 6).

Table 6. Water quality field parameters—Sand Hollow Creek Follow-Up Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Field Measurements			
			Water Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH[a]
2232	—	5/21/2014	14.3	523	7.04	7.52
2232	—	9/15/2014	14.56	736	—	7.09
2232	—	9/17/2014	14.64	659	—	7.09

Notes: (—) = data are unavailable or were not analyzed
[a] Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5–8.5. NSDWR standards are recommended limits for public water systems and are used with private wells to evaluate water quality.

The May 21 and September 15 samples were analyzed for nitrate, nitrite, total coliform, and *E. coli*. Samples were submitted to the Idaho Bureau of Laboratories (IBL) in Boise, Idaho, for analysis. The reported results for these samples can be found in Table 7.

Nitrogen isotope samples were collected on May 21 and September 17 and frozen and stored at DEQ pending nitrate analysis. After DEQ received nitrate analysis results, the nitrogen isotope samples were sent to the University of Arizona Environmental Isotope Geosciences Laboratory in Tucson, Arizona, for nitrogen isotope analysis (Table 7).

Table 7. Inorganic, nutrient, and bacteria results—Sand Hollow Creek Follow-Up Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Inorganic and Nutrient Concentrations			Bacteria[b]		
			Nitrite[a]	Nitrate[a]	$\delta^{15}N$		Total Coliform	E. coli
			(mg/L)		(‰)		(MPN/100 mL)	
Standard:			***1***	***10***	***NA***		***1 cfu/100 mL***	***<1 cfu/100 mL***
2232	—	5/21/2014	<0.030	9.62	6.0		12.2	—
2232	—	9/15/2014	<0.030	**17.7**	—		NR	**1,119.9**
2232	—	9/17/2014	—	—	7.8		—	—

Notes: Bolded red numbers indicate either an EPA's National Primary Drinking Water Regulation standard, expressed as a maximum contaminant level (MCL), or an Idaho Ground Water Quality Rule (IDAPA 58.01.11.200) standard was reached or exceeded. These regulations are applicable for public water systems only and are used to evaluate water quality in private wells. (—) = data are unavailable or were not analyzed. NR = not recorded.
[a] Contaminant with a National Primary Drinking Water Regulation standard.
[b] Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

DEQ also collected a sample for immunoassay testing on September 15, 2014, due to an IDWR Statewide Ambient Ground Water Monitoring Program effort. An immunoassay is a biochemical test that measures the presence or concentration of a macromolecule in a solution through the use of an antibody or immunoglobulin. The immunoassay samples were submitted to IBL for analysis of four selected analytes: 17-Beta estradiol, caffeine, sulfamethoxazole, and BPA (Table 8):

- 17-beta estradiol is a human sex hormone and steroid.
- Caffeine is a human organic waste indicator.

- Sulfamethoxazole is an antibiotic for human use. The FDA has prohibited the use of this antibiotic in animals used to produce milk or meat for human consumption.
- BPA is a chemical used in the production of plastic containers.

Table 8. Immunoassay results—Sand Hollow Creek Follow-Up Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Immunoassay Measurements			
			17-Beta Estradiol (ng/L)	Caffeine	Sulfamethoxazole	Bisphenol A
				(µg/L)		
2232	—	9/15/2014	<2.5	<0.175	<0.025	<0.05

Note: (—) = data are unavailable or were not analyzed.

Nitrate Results

In the May 21 sample, the reported nitrate concentration was 9.62 mg/L, which is slightly below the nitrate MCL of 10 mg/L. In the September 15 sample, the reported nitrate concentration was 17.7 mg/L, which is above the nitrate MCL of 10 mg/L and a significant increase from the May result.

Nitrite Results

No samples contained nitrites above the laboratory reportable detection limit of 0.030 mg/L.

Nitrogen Isotope Results

Nitrogen isotope analysis was completed on both the May 21 and September 17 samples (Table 7). Well 2232 had $\delta^{15}N$ results of 6.0 and 7.8‰, indicating the source of nitrogen is from either organic nitrogen in soil or a mixed nitrogen source (Table 4).

Bacteria Results

Total coliform bacteria are common in the environment (such as soil) and in the intestines of animals and are generally not harmful. *E. coli* bacteria, a type of coliform, are found in animal fecal matter. The presence of *E. coli* in drinking water provides strong evidence that human or animal fecal matter is present; therefore, a greater potential for pathogenic organisms exists. Total coliform and *E. coli* concentrations are reported in the most probable number per 100 milliliters (MPN/100 mL).

In the May 21 sample, the reported total coliform concentration was 12.2 MPN/100 mL. Due to a lab error, the sample was not quantified for *E. coli*.

In the September 15 sample, the reported *E. coli* concentration was 1,119.9 MPN/100 mL. The TC concentration for this sample was not documented by lab personnel. The concentration of TC on September 15, 2014, is at least equal to or greater than the reported concentration of *E. coli* for the same sample (1,119.9 MPN/100 mL) since *E. coli* is a type of coliform.

Immunoassay Results

On September 15, Well 2232 was sampled for 17-beta estradiol, caffeine, sulfamethoxazole, and BPA through an immunoassay analysis. The reported results for all four constituents in the immunoassay test were below the laboratory detection limit (Table 8). Currently, these constituents are not subject to any proposed or promulgated national primary drinking water regulations. However, 17-beta estradiol, an estrogenic hormone and used in pharmaceuticals, is included in EPA's draft contaminant candidate list – 4 (CCL-4). Contaminants on the CCL are known to occur in public water systems and may require future regulation under the SDWA.

2.1.2.3 Conclusions

In response to a complaint, DEQ conducted a sampling project in 2013 to evaluate ground water quality in the Sand Hollow Creek area southwest of the Rim Fire Ranch property. During the 2013 sampling event, DEQ found that the water in Well 2232 had elevated nitrate concentrations. Due to the elevated nitrate concentrations in 2013, DEQ took additional samples from Well 2232 in 2014. Those samples were analyzed for nitrate, nitrite, nitrogen isotope, and bacteria (total coliform and *E. coli*). The well was also evaluated for the presence of 17-Beta estradiol, caffeine, sulfamethoxazole, and BPA through an immunoassay analysis.

The nitrate results showed significant variability between May and September samples, suggesting a potential seasonality of the nitrate concentrations. The September 2014 nitrate concentration of 17.7 mg/L is similar to the September 2013 concentration of 19.0 mg/L, which further substantiates the suspicion of a seasonal component to the nitrate concentrations at Well 2232. The $\delta^{15}N$ sample collected on September 17, 2014, had a $\delta^{15}N$ ratio of 7.8‰. Both 2014 $\delta^{15}N$ results were lower than the 2013 result of 9.1‰, suggesting there is variability in nitrogen sources.

Both sampling events in 2014 at Well 2232 resulted in positive detections of bacteria. The May sampling effort detected TC in the well water; however, due to a lab error, *E. coli* was not analyzed. The September sample again confirmed the presence of bacteria at this well with an *E. coli* detection of 1,119.9 MPN/100 mL. When conducting the laboratory method for bacteria, IBL made an assumption *E. coli* was the only constituent of interest and did not record the concentration of total coliform. Since *E. coli* is a form of coliform, it is understood that the TC value at Well 2232 in September was equal to or greater than 1,119.9 MPN/100 mL. Before DEQ could conduct follow-up sampling in response to the high *E. coli* concentration, the homeowner disinfected the well.

Through ISDA facility inspection sampling efforts, the dairy production well showed an increase in nitrate concentration from 11.6 mg/L in 2013 to 13.10 mg/L in 2014.

2.1.2.4 Recommendations

Additional ground water sampling and analyses will be conducted to monitor changes in ground water quality and further evaluate the ground water chemistry. DEQ will collect seasonal samples from Well 2232 in 2015 in an attempt to determine if there is seasonal variability in the nitrate and bacteria concentrations.

2.1.3 Glenns Ferry Nitrate Priority Area Ground Water Monitoring Project

2.1.3.1 Purpose and Background

This ground water monitoring project was designed to evaluate the water quality and nitrate concentrations in the Glenns Ferry NPA in Elmore County. In 2008, the Glenns Ferry NPA ranked as the 17th most impacted NPA in Idaho. In 2014, the Glenns Ferry NPA was ranked the 19th most impacted NPA and was found to have no observable trend (DEQ 2014a). The predominant land uses in the Glenns Ferry NPA are agricultural and residential. All of the residences located within the NPA, but outside Glenns Ferry city limits, are served by private wells.

Elmore County is located along the northeast margin of the central western Snake River Plain (Shervais et al. 2002). The western Snake River Plain is a deep structural depression (basin) bounded by major northwest-trending faults (Newton 1991). A major lake system named Lake Idaho developed in the basin and existed from about 9.5 to 1.7 million years ago (Wood and Clemens 2002). Volcanic ash and lake and stream sediments, including clay, silt, sand, and gravel, were deposited in the basin.

DEQ's review of the IDWR well driller's reports for wells located within the project area indicated the subsurface generally consists of layers of clay, sand, and gravel with some basalt. The depth to ground water shown on well driller's reports ranged from 13 to 239 feet bgs. The wells sampled for this project were completed at depths ranging from 24 to 738 feet and were generally completed into water-bearing sand and/or gravel layers. The Glenns Ferry NPA is located on both the north and south sides of the Snake River. IDWR's regional ground water flow map (IDWR 2014) shows ground water flow within the NPA is generally toward the Snake River (Figure 7).

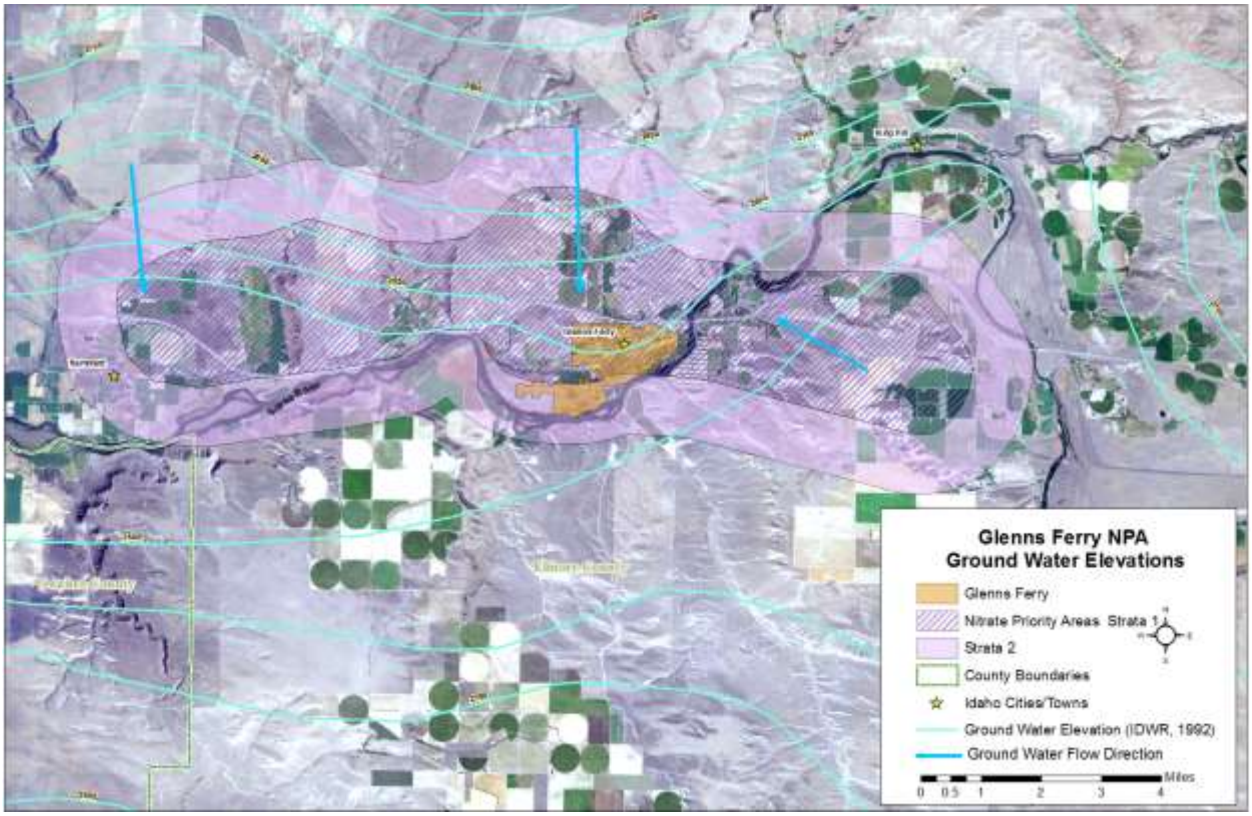


Figure 7. Ground water elevation contours—Glenns Ferry Nitrate Priority Area Ground Water Monitoring Project.

In 2014, DEQ collected ground water samples from 11 domestic or irrigation wells in the Glenns Ferry NPA using procedures outlined in the QAPP (DEQ 2014i). Program objectives, design, and well selection processes are identified in the regional ground water monitoring network design (DEQ 2011a). DEQ analyzed the ground water samples for common water quality analytes including nitrate and bacteria (total coliform and *E. coli*) to assess the water quality in the project area.

2.1.3.2 Methods and Results

A statistical process, developed for DEQ by Dr. Kirk Steinhorst of the University of Idaho (Steinhorst 2011), was used to determine the number of samples required within the Glenns Ferry NPA (Stratum 1) and a 1-mile buffer zone around the Glenns Ferry NPA (Stratum 2) to ensure the sampling event was statistically valid. The Glenns Ferry NPA is a small monitoring area as defined in the regional ground water monitoring network design (DEQ 2011a); therefore, the census sampling method (sampling all qualifying wells) was chosen.

Permission was obtained from the well owners for DEQ staff to access the 11 wells and collect samples for laboratory analysis. A query of DEQ's ground water database indicated the 11 wells in question had not been previously sampled by DEQ, IDWR or ISDA.

Samples were collected in October 2014 from each well in accordance with DEQ's regional nitrate priority area ground water monitoring activities Boise region QAPP (DEQ 2014i) and the Glenns Ferry NPA regional ground water monitoring network FSP (DEQ 2014d). Water quality field parameters (i.e., pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 9).

Table 9. Water quality field parameters—Glenns Ferry Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Field Measurements			
			Water Temperature (°C)	pH[a]	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
2369	738	10/14/2014	26.53	7.93	655	1.46
2370	24	10/14/2014	18.23	7.33	801	6.66
		10/22/2014	17.83	7.44	8.7	5.72
2371	112	10/14/2014	18.65	7.86	867	1.67
2372	60	10/14/2014	16.36	7.51	881	9.00
		10/22/2014	16.07	7.52	911	8.44
2373	500	10/14/2014	22.44	*8.78*	420	1.64
2374	332	10/14/2014	21.05	8.13	429	1.25
2378	36	10/20/2014	16.02	7.53	739	6.92
2375	240	10/14/2014	17.73	7.84	863	6.58
2377	360	10/20/2014	17.89	7.45	685	1.33
2376	165	10/14/2014	17.02	7.63	1110	7.95
2468	Unknown	10/20/2014	21.97	7.50	492	1.39

[a] Contaminant with a National Secondary Drinking Water Regulation standard. Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be used to evaluate water quality in private wells.

Samples collected from each well were analyzed for nitrate, nitrite, total coliform, and *E. coli* (Table 10). Wells with a DO less than 2.00 mg/L as determined by field measurements were also analyzed for ammonia as required by the FSP. Nitrogen isotope samples were collected at each sampling location and frozen and stored at DEQ pending nitrate analysis. After DEQ received nitrate analysis results, those nitrogen isotope samples from wells with nitrate concentrations greater than 5 mg/L were sent to the University of Arizona Environmental Isotope Geosciences Laboratory in Tucson, Arizona, for nitrogen isotope analysis.

Table 10. Nutrient and bacteria results—Glenns Ferry Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Nutrient Concentrations				Bacteria[b]	
			Ammonia	Nitrate[a]	Nitrite[a]	$\delta^{15}N$	Total Coliform	*E. coli*
			(mg/L)			(‰)	(MPN/100 mL)	
Primary or Secondary Standard:			***NA***	***10***	***1***	***NA***	***1 cfu/100 mL***	***<1 cfu/100 mL***
2369	738	10/14/2014	3.2	0.217	<0.30	—	NR	<1.0
2370	24	10/14/2014	—	7.37	<0.30	8.1	NR	<1.0
		10/22/2014	—	—	—	—	6.3	<1.0
2371	112	10/14/2014	0.78	<0.18	<0.30	—	NR	<1.0
2372	60	10/14/2014	—	3.58	<0.30	—	NR	<1.0
		10/22/2014	—	—	—	—	547.5	<1.0
2373	500	10/14/2014	0.58	<0.18	<0.30	—	NR	<1.0
2374	332	10/14/2014	1.3	<0.18	<0.30	—	NR	<1.0
2378	36	10/20/2014	—	2.13	<0.30	—	<1.0	<1.0
2375	240	10/14/2014	—	<0.18	<0.30	—	NR	<1.0
2377	360	10/20/2014	2.6	0.528	<0.30	—	<1.0	<1.0
2376	165	10/14/2014	—	**14.4**	<0.30	4.0	NR	<1.0
2468	Unknown	10/20/2014	0.81	<0.18	<0.30	—	<1.0	<1.0

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. These regulations are applicable for public water systems only but are recommended limits and can be used to evaluate water quality in private wells. (—) = data are unavailable or were not analyzed; NR indicates no laboratory results

[a] Contaminant with a National Primary Drinking Water Regulation standard.

[b] Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

Nitrate Results

The reported nitrate concentrations ranged from <0.18 mg/L to 14.4 mg/L; 2 of the 11 wells sampled had a nitrate concentration of 5 mg/L or greater (2370 and 2376). The nitrate MCL of 10 mg/L was exceeded in sample 2376. The spatial distribution of nitrate concentrations is shown in Figure 8.

Bacteria Results

Due to a laboratory reporting error, total coliform (TC) results were not reported with the October 14 *E. coli* results. None of the 11 wells tested positive for *E. coli*. The laboratory ran the October 14 samples for TC after the error was discovered, and two samples (sites 2370 and 2372) were positive for TC. Unfortunately, the holding time had been exceeded and the results could not be used. In an effort to confirm the positive TC results, sites 2370 and 2372 were resampled on October 22, 2014. The reported TC concentrations from all sites ranged from <1 MPN/100 mL to 547.5 MPN/100 mL. The two replacement samples were negative for *E. coli*.

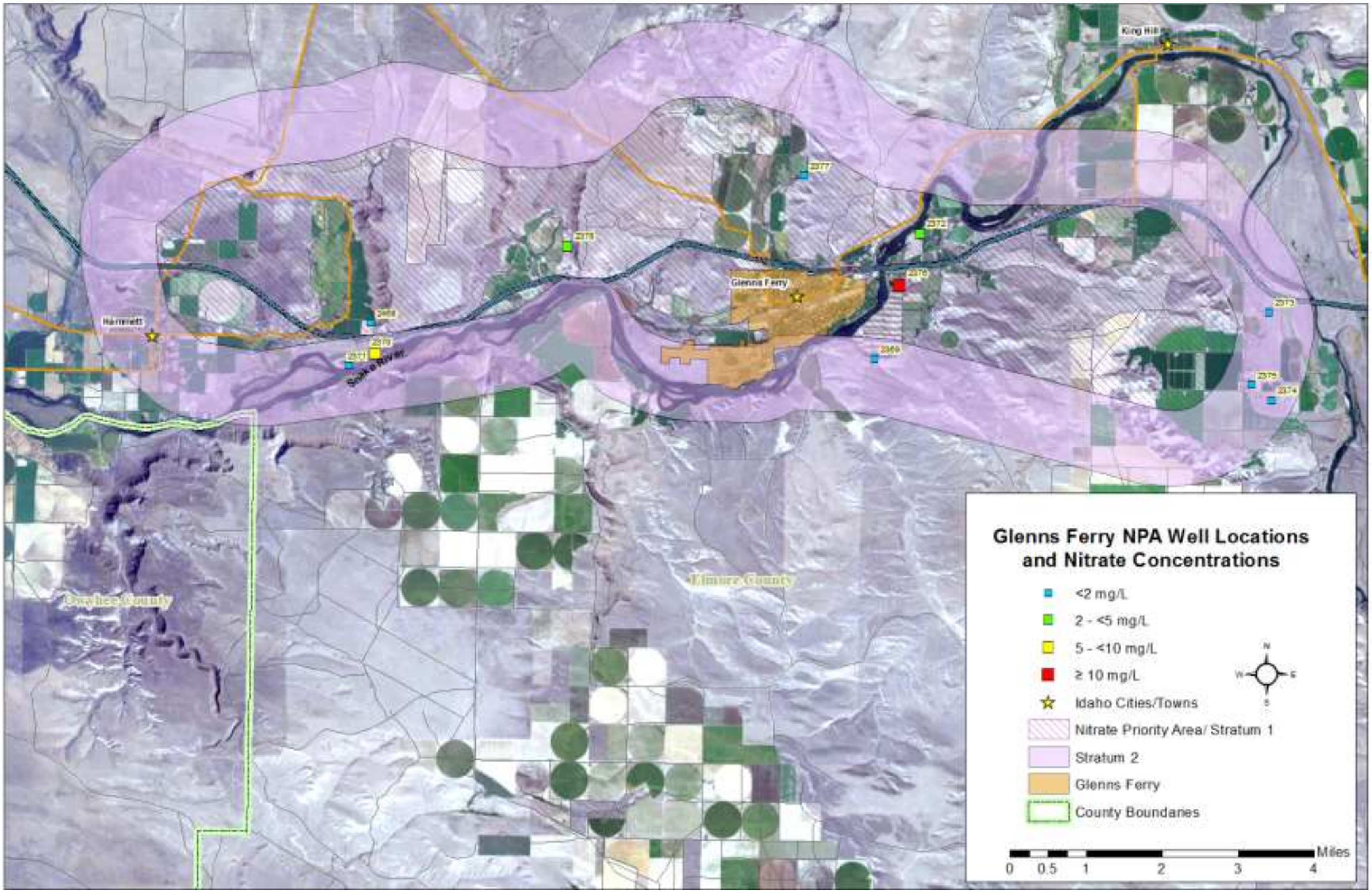


Figure 8. Sample locations and nitrate concentrations—Glenns Ferry Nitrate Priority Area Ground Water Monitoring Project.

Nitrogen Isotope Results

Only two samples (2370 and 2376) were submitted for $\delta^{15}N$ analysis for this project. The $\delta^{15}N$ ratios for Well 2370 and Well 2376, 8.1‰ and 4.0‰, respectively, were both between 4‰ and 9‰, indicating the source of nitrates in the ground water is most likely from organic nitrogen in soil or a mixed nitrogen source (Seiler 1996).

2.1.3.3 Conclusions

The Glenns Ferry NPA is unique due to its small size, with clusters of residences among large agricultural fields. The primary land uses in the Glenns Ferry NPA are agricultural and residential. The primary agricultural use is irrigated cropland.

The criterion for an NPA is at least 25% of the wells sampled within the area meet or exceed 5 mg/L nitrate. This value is half the MCL of 10 mg/L. In this project, 2 of the 11 wells (18%) had nitrate concentrations greater than 5 mg/L. Within the NPA (stratum 1), 1 well (2376) out of 5 sampled (20%) had a nitrate concentrations above the nitrate MCL of 10 mg/L. A total of 6 wells were sampled within stratum 2; 1 of the 6 wells (~17%) was greater than 5 mg/L.

The $\delta^{15}N$ results suggest a mixture of nitrate sources, including fertilizer and organic sources such as crop decay (e.g., legume crop plow down) and/or organic nitrogen in the soil. This mixture of nitrogen sources is typical of an agricultural area.

Bacteria sampling resulted in two detections of total coliform.

2.1.3.4 Recommendations

DEQ recommends that property owners with private domestic drinking water wells sample their well—prior to any water treatment system and as close to the well as possible—on an annual basis. Central District Health Department can provide Elmore County property owners with information and guidance on well sampling and interpretation of results.

In addition, property owners may benefit from education on the use of commercial fertilizers and pesticides on their lawns and gardens and education on proper maintenance of their wells and septic systems.

DEQ has assisted Elmore County in developing and implementing a ground water quality improvement plan. This plan includes outreach activities for private well owners and agricultural operators aimed at reducing source water contamination, including activities to reduce nitrate contamination.

In addition, Elmore County has enacted planning and zoning regulations to protect ground water supplying public water systems.

2.1.4 Mountain Home Nitrate Priority Area Ground Water Monitoring Project

2.1.4.1 Purpose and Background

This ground water monitoring project was designed to evaluate the water quality and nitrate concentrations in the Mountain Home NPA in Elmore County. In 2008, the Mountain Home

NPA ranked as the 11th most impacted NPA in Idaho. In 2014, it remained the 11th most impacted area and had no observable trend. The primary land uses in the Mountain Home NPA are agricultural and residential. The primary agricultural use is irrigated cropland. All of the residences within the NPA are served by private wells. The city waste lagoons are located northeast of the NPA, with wastewater reuse areas located within the NPA.

Elmore County primarily consists of two geologic provinces: the Idaho Batholith in the north and the western Snake River Plain in the south. The Mountain Home NPA is located in the southern geologic province along the northeast margin of the central western Snake River Plain (Shervais et al. 2002). A major lake system named Lake Idaho developed in the basin and existed from about 9.5 to 1.7 million years ago (Wood and Clemens 2002). Volcanic ash and lake and stream sediments, including clay, silt, sand, and gravel, were deposited in the basin. In the central part of the western Snake River Plain near Mountain Home, basalt overlies and is interbedded with the basin sediments (Newton 1991).

DEQ’s review of the IDWR well driller’s reports for wells located within the project area indicated the subsurface consists of basalt with limited interbedded layers of sand and clay at a few well locations. The wells sampled for this project were generally completed at depths of 416 to 606 feet, with many wells cased to shallow depths (less than 50 feet) and therefore open to any water-bearing units within the basalt from the bottom of the casing to the base of the well. Water-bearing units within the basalt include layers of ash, cinder, and broken basalt, which represent the tops or bases of individual basalt flows, and sands and gravels at the base of the basalt. Approximately one-half of the wells penetrate through the basalt to water-bearing clay, sand, and/or gravel layers that likely represent lake or stream deposits. The depth to ground water shown on well driller’s reports for the majority of the project wells was 350 to 425 feet bgs. Based on IDWR’s regional ground water flow map (IDWR 2014), ground water flow within the NPA is generally southwest towards the Snake River (Figure 9).

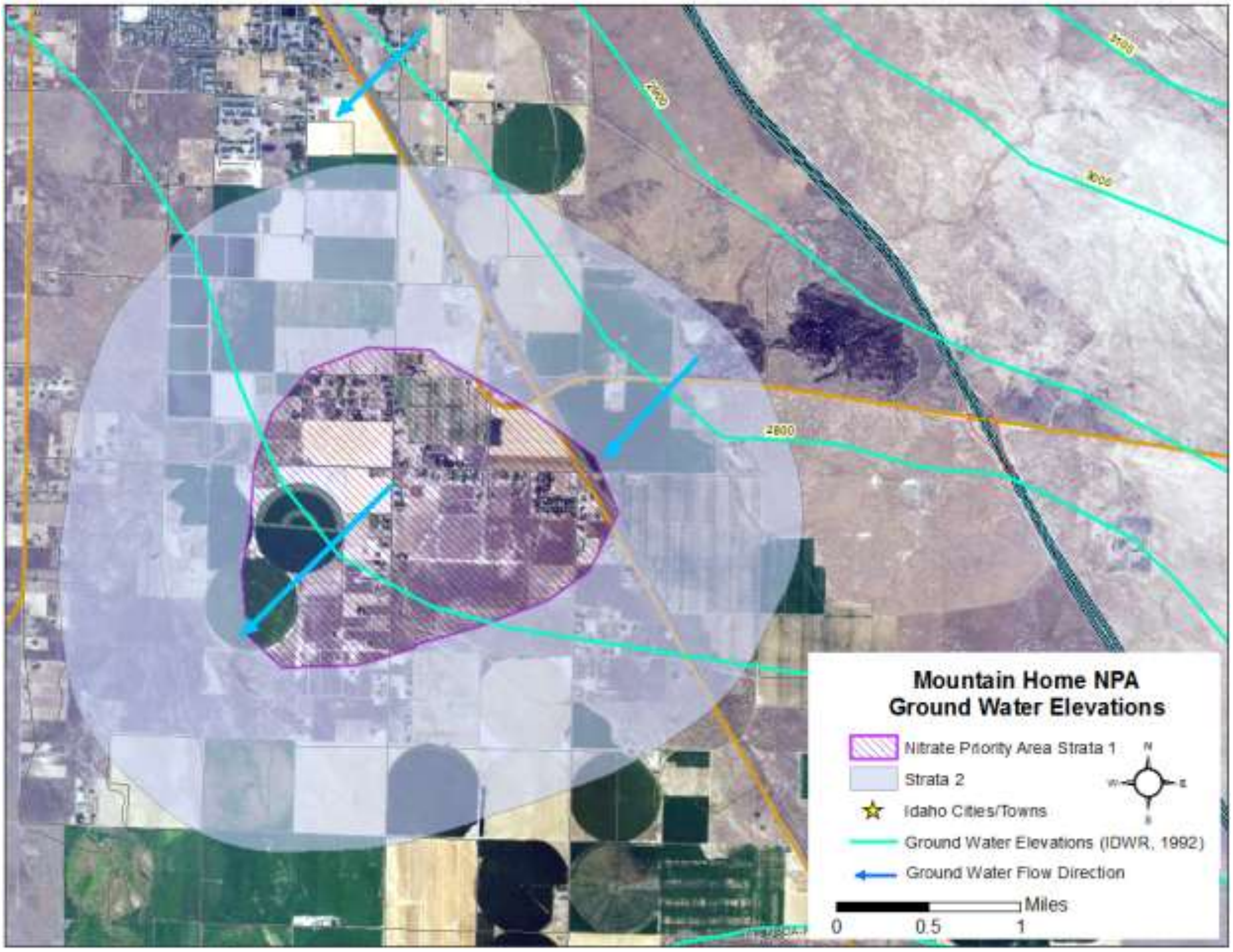


Figure 9. Ground water elevation contours—Mountain Home Nitrate Priority Area Ground Water Monitoring Project.

In 2014, DEQ collected ground water samples from 19 domestic or irrigation wells in the Mountain Home NPA using procedures outlined in the QAPP (DEQ 2014i). Program objectives, design, and well selection processes are identified in the regional ground water monitoring network design (DEQ 2011a). DEQ analyzed the ground water samples for common water quality analytes including nitrate and bacteria (total coliform and *E. coli*) to assess water quality in the project area.

2.1.4.2 Methods and Results

A statistical process, developed for DEQ by Dr. Kirk Steinhorst of the University of Idaho (Steinhorst 2011), was used to determine the number of samples required within the Mountain Home NPA (Stratum 1) and a 1-mile buffer zone around the Mountain Home NPA (Stratum 2) to ensure the sampling event was statistically valid. The Mountain Home NPA is a small monitoring area as defined in the regional ground water monitoring network design (DEQ 2011a); therefore, the census sampling method (sampling all qualifying wells) was chosen. A total of 19 wells were sampled as part of this project, with 12 wells in stratum 1 and 7 wells in stratum 2.

Due to the small size of the project area and limited availability of wells, 8 wells previously sampled by ISDA (2304, 2334, 2359, 2362, 2364, 2366, 161, and 954) were included in the 2014 sampling effort. Permission was obtained from the well owners for DEQ staff to access all 19 wells and collect samples for laboratory analysis.

Samples were collected in September 2014 from each well in accordance with DEQ's regional nitrate priority area ground water monitoring activities Boise region QAPP (DEQ 2014i) and the Mountain Home Nitrate Priority Area regional ground water monitoring network FSP (DEQ 2014e). Water quality field parameters (i.e., pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 11).

Table 11. Water quality field parameters—Mountain Home Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Field Measurements			
			Water Temperature (°C)	pH[a]	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
161	463	9/22/2014	20.57	7.97	425	9.05
954	600	9/23/2014	15.03	6.74	1240	1.67
2144	550	9/23/2014	18.78	8.17	371	9.41
2242	570	9/22/2014	25.52	7.9	325	5.64
2304	536	9/22/2014	18.2	7.86	589	10.4
2308	487	9/22/2014	20.69	7.84	535	8.48
2320	521	9/22/2014	17.55	7.69	649	9.65
2334	599	9/22/2014	26.28	7.95	316	4.52
2358	440	9/22/2014	21.89	7.89	501	9.01
2359	575	9/22/2014	13.45	8.1	326	7.05
2360	580	9/22/2014	25.25	7.97	328	4.01
2361	532	9/22/2014	19.86	8.1	422	8.89
2362	567	9/22/2014	25.45	7.94	310	5.32
2363	525	9/23/2014	17.15	7.66	764	8.21
2364	525	9/22/2014	18.62	7.68	739	10.05
2365	550	9/23/2014	14.88	7.34	1010	9.95
2366	446	9/23/2014	18.42	8.24	350	9.25
2367	496	9/22/2014	14.44	7.63	955	11.48
2368	470	9/23/2014	19.58	7.86	527	8.19

[a] Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be used to evaluate water quality in private wells.

Samples collected from each well were analyzed for nitrate, nitrite, total coliform, and *E. coli* (Table 12). Wells with a DO less than 2.00 mg/L as determined by field measurements were also analyzed for ammonia as required by the FSP. Nitrogen isotope samples were collected at each sampling location and frozen and stored at DEQ pending nitrate analysis. After DEQ received nitrate analysis results, those nitrogen isotope samples from wells with nitrate concentrations greater than 5 mg/L were sent to the University of Arizona Environmental Isotope Geosciences Laboratory in Tucson, Arizona, for nitrogen isotope analysis.

Table 12. Nutrient and bacteria results—Mountain Home Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Nutrient Concentrations				Bacteria[b]	
			Ammonia	Nitrate[a]	Nitrite[a]	$\delta^{15}N$	Total Coliform	*E. coli*
			(mg/L)			(‰)	(MPN/100 mL)	
Primary or Secondary Standard:			***NA***	***10***	***1***	***NA***	***1 cfu/100 mL***	***<1 cfu/100 mL***
161	463	9/22/2014	—	3.47	<0.30	—	<1	<1
954	600	9/23/2014	RD	<0.18	<0.30	—	<1	<1
2144	550	9/23/2014	—	2.55	<0.30	—	1.0	<1
2242	570	9/22/2014	—	1.37	<0.30	—	1119.9	<1
2304	536	9/22/2014	—	5.53	<0.30	6.8	<1	<1
2308	487	9/22/2014	—	5.06	<0.30	7.3	<1	<1
2320	521	9/22/2014	—	7.76	<0.30	6.8	<1	<1
2334	599	9/22/2014	—	1.08	<0.30	—	<1	<1
2358	440	9/22/2014	—	4.44	<0.30	—	<1	<1
2359	575	9/22/2014	—	2.6	<0.30	—	<1	<1
2360	580	9/22/2014	—	1.14	<0.30	—	<1	<1
2361	532	9/22/2014	—	2.86	<0.30	—	<1	<1
2362	567	9/22/2014	—	1.07	<0.30	—	12.1	<1
2363	525	9/23/2014	—	2.4	<0.30	—	<1	<1
2364	525	9/22/2014	—	**10.1**	<0.30	6.4	<1	<1
2365	550	9/23/2014	—	3.28	<0.30	—	<1	<1
2366	446	9/23/2014	—	2.01	<0.30	—	<1	<1
2367	496	9/22/2014	—	**10.8**	<0.30	10.9	<1	<1
2368	470	9/23/2014	—	4.31	<0.30	—	<1	<1

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was reached or exceeded.
(—) = data are unavailable or were not analyzed; RD indicates rejected data due to sampling, laboratory, or equipment errors.
[a] Contaminant with a National Primary Drinking Water Regulation standard.
[b] Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded cells) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

Nitrate Results

The reported nitrate concentrations ranged from <0.18 mg/L to 10.8 mg/L; 5 of the 19 wells sampled (2304, 2308, 2320, 2364, and 2367) had nitrate concentration of 5 mg/L or greater. The nitrate MCL of 10 mg/L was exceeded in 2 samples (2364 and 2367). The spatial distribution of nitrate concentrations is shown in Figure 10.

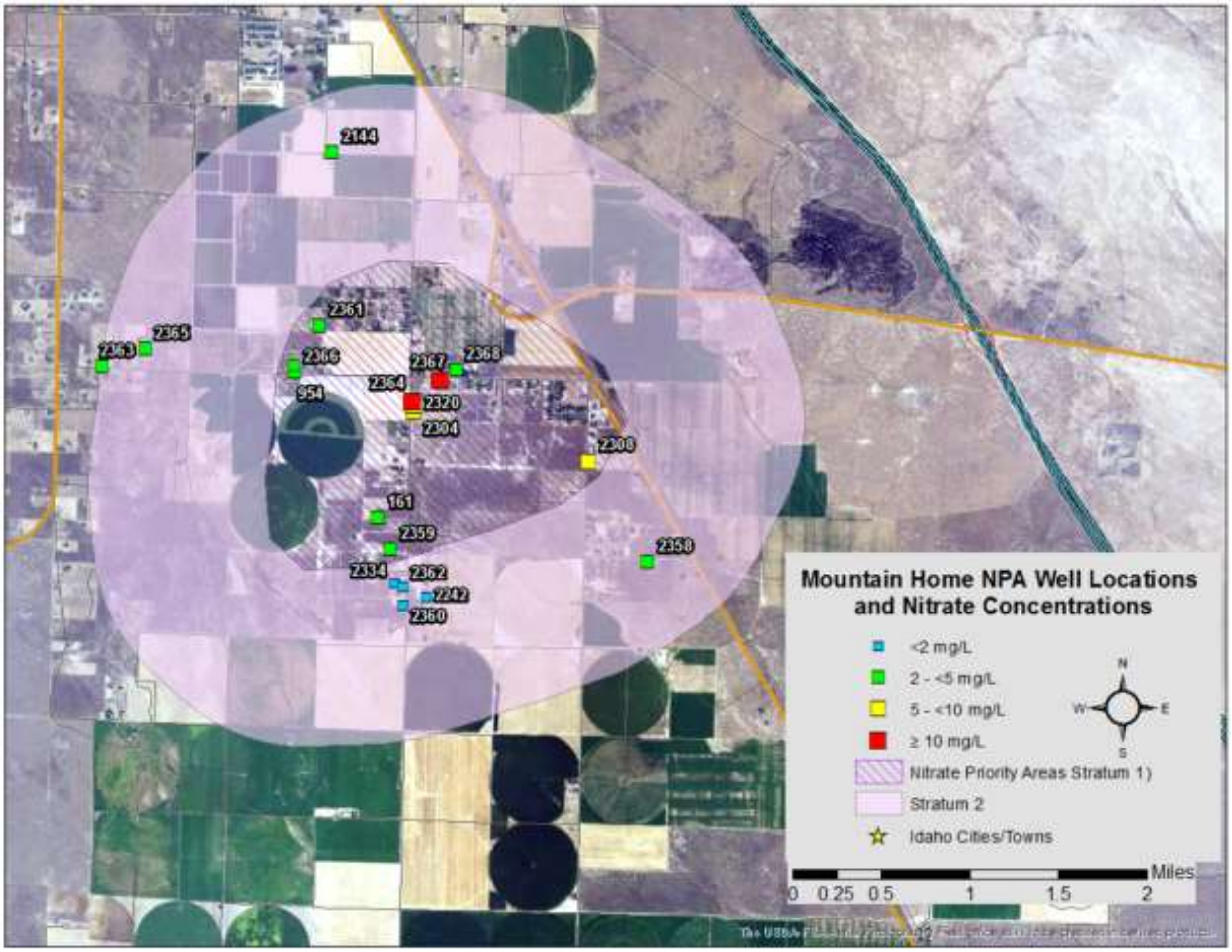


Figure 10. Sample locations and nitrate concentrations—Mountain Home Nitrate Priority Area Ground Water Monitoring Project.

Bacteria Results

Three of the 19 project wells (2144, 2242, and 2362) had positive detections of total coliform (TC) bacteria. The reported positive detections of total coliform concentrations ranged from 1.0 MPN/100 mL to 1119.9 MPN/100 mL (Table 12). None of the 19 wells tested positive for *E. coli*.

Nitrogen Isotope Results

Nitrogen isotope ratios, denoted as $\delta^{15}N$, can be helpful in determining the potential sources of nitrate in the ground water. Nitrogen isotope ratios were determined for all samples with nitrate concentrations greater than or equal to 5 mg/L (Table 12). Nitrogen from human or animal waste and fertilizer sources has distinguishable $\delta^{15}N$ signatures. The $\delta^{15}N$ results from this project ranged from 6.4‰ to 10.9‰. Four wells (2304, 2308, 2320, and 2364) had $\delta^{15}N$ ratios between +4‰ and +9‰, indicating the source of nitrate in the ground water is most likely from organic nitrogen in soil or a mixed nitrogen source. One well (2367) had a $\delta^{15}N$ ratio greater than 9‰ indicating the source of nitrates in the ground water is most likely from animal or human waste (Table 4).

2.1.4.3 Conclusions

The ground water quality data from the Mountain Home NPA identified nitrate impacts to ground water within the study area. The data also indicate that the source of nitrate is likely from multiple sources of nitrogen.

The Mountain Home NPA is unique due to its small size, with clusters of residences among large agricultural fields. In addition, the wells located in the Mountain Home NPA are deep wells that have been bored through basalt and other volcanic layers. Many of the well casings do not extend the full depth of the well bore, which allows the mixing of water from several saturated zones. While the general assumption is that ground water in the area flows toward the Snake River, the lithology of the region may allow for preferential flow within the basalt layers.

The primary land uses in the Mountain Home NPA are agricultural and residential. The primary agricultural use is irrigated cropland. The city waste lagoons are located northeast of the NPA, with wastewater reuse areas located within the NPA.

The criterion for an NPA is at least 25% of the wells sampled within the area meet or exceed 5 mg/L nitrate. This value is half the MCL of 10 mg/L. In this project, 5 of the 19 wells sampled (26%) had nitrate values greater than 5 mg/L. The nitrate MCL of 10 mg/L was exceeded in 2 of these samples. In stratum 1, 5 of the 11 (45%) wells had nitrate concentrations greater than 5 mg/L. These wells were located in the center and eastern portion of the Mountain Home NPA. None of the 8 wells sampled in stratum 2 had nitrate concentrations greater than 5 mg/L.

The $\delta^{15}N$ results from the majority of the samples suggest a mixture of nitrate sources, including fertilizer and organic sources such as crop decay (e.g., legume crop plow down) and/or organic nitrogen in the soil. This mixture of nitrogen sources is typical of an agricultural area. The $\delta^{15}N$ ratio from Well 2367 suggests an animal or human waste source of nitrogen.

2.1.4.4 Recommendations

DEQ recommends that property owners with private domestic drinking water wells sample their well—prior to any water treatment system and as close to the well as possible—on an annual basis. Central District Health Department can provide Elmore County property owners with information and guidance on well testing and result interpretation.

In addition, property owners may benefit from education on the use of commercial fertilizers and pesticides on their lawns and gardens and education on proper maintenance of their wells and septic systems.

DEQ has assisted Elmore County in developing and implementing ground water quality improvement and drinking water source protection plans. These plans include outreach activities for private well owners and agricultural operators aimed at reducing source water contamination, including activities to reduce nitrate contamination.

In addition, Elmore County has enacted planning and zoning regulations to protect ground water supplying public drinking water systems.

2.1.5 Weiser Nitrate Priority Area Ground Water Monitoring Project

2.1.5.1 Purpose and Background

This ground water monitoring project was designed to evaluate the water quality and nitrate concentrations in the Weiser NPA in Washington County. In 2008, the Weiser NPA ranked as the 3rd most impacted NPA in Idaho. In 2014, it ranked 2nd. During this reevaluation of the Weiser NPA, no observable trend was observed. The predominant land uses in the Weiser NPA are agricultural and residential. The residences within the City of Weiser are served by the City of Weiser public water system. A few of these residences retained their original wells and use these wells for irrigation purposes. All of the residences outside the city limits of Weiser are served by private wells.

The southernmost portion of Washington County, which includes the Weiser NPA, is part of the western Snake River Plain. The western Snake River Plain is a deep structural depression (basin) bounded by major northwest-trending faults (Newton 1991). A major lake system named Lake Idaho developed in the basin and existed from about 9.5 to 1.7 million years ago (Wood and Clemens 2002). Volcanic ash and lake and stream sediments, including clay, silt, sand, and gravel, were deposited in the basin (Newton 1991). The area surrounding Weiser contains Lake Idaho-related sediments (clay, silt, and sand) and more recent stream- and wind-deposited sediments (Digital Atlas of Idaho 2014).

DEQ’s review of the IDWR well driller’s reports for wells located within the project area indicated the subsurface consists of sand, gravel, and clay. Project wells were relatively shallow, with 32 of the 37 wells completed to a depth of 75 feet bgs or less. The majority of the wells were completed in sand and gravel units directly above a clay layer identified by well drillers in the driller’s reports as “blue clay.” This clay is often present in various thicknesses and elevations throughout the central and western Boise River valley. The clay forms confining units that can separate shallow aquifers from deeper zones (Petrich and Urban 2004). The well driller’s reports for 30 of the 37 project wells reported a blue clay layer at depths ranging from 26 to 66 feet, and almost all of these wells were completed in sand and gravel layers directly above the blue clay. The well driller’s reports for the project wells reported very shallow depths to water, generally ranging from 8 to 20 feet bgs. Based on IDWR’s regional ground water flow map (IDWR 2014), the ground water flow direction within the Weiser NPA is generally southwest towards the Snake River (Figure 11).

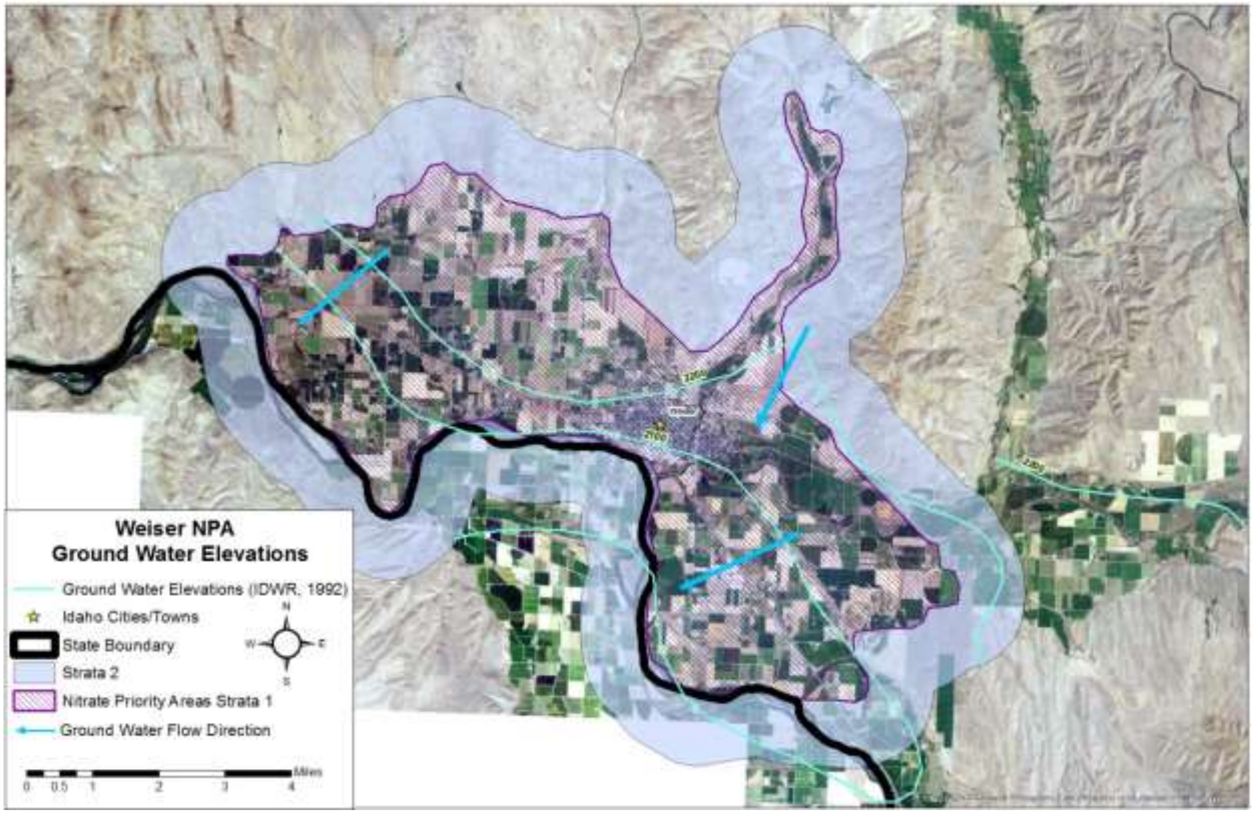


Figure 11. Ground water elevation contours—Weiser Nitrate Priority Area Ground Water Monitoring Project.

In 2014, DEQ collected ground water samples from 37 domestic or irrigation wells in the Weiser NPA using procedures outlined in the QAPP (DEQ 2014i). Program objectives, design, and well selection processes are identified in the regional ground water monitoring network design (DEQ 2011a). DEQ analyzed the ground water samples for common water quality analytes including nitrate and bacteria (total coliform and *E. coli*) to assess the water quality in the project area.

2.1.5.2 Methods and Results

A statistical process, developed for DEQ by Dr. Kirk Steinhorst of the University of Idaho (Steinhorst 2011), was used to determine the number of samples that would have to be taken within the NPA (Stratum 1) to ensure the sampling event was statistically valid. The statistical model determined that 32 wells located in Stratum 1 and 9 wells in Stratum 2 would need to be sampled to meet a 90% confidence level that the estimated mean is within 10% of the true mean. The model also determined the size of each sampling unit would be one quarter section. The total number of sections in Stratum 1 were randomized separately to determine which sections would be sampled. For this study, 32 wells were selected for sampling within the NPA Stratum 1. Permission was obtained to sample these 32 wells.

The portion of Stratum 2 (a 1-mile wide buffer area surrounding Stratum 1) that can be sampled is very limited, and obtaining the recommended 9 wells was unattainable. While 8 wells in Stratum 2 met the design criteria, DEQ received permission for only 6 of the 8 wells. However, 1 well did not have a sampling point prior to a filtration system, so 5 wells were sampled in Stratum 2.

Samples were collected in May 2014 from each of the 37 wells in accordance with DEQ's regional nitrate priority area ground water monitoring activities Boise region QAPP (DEQ 2014i) and the Weiser Nitrate Priority Area regional ground water monitoring network FSP (DEQ 2014f). Water quality field parameters (i.e., pH, temperature, specific conductivity, and DO) were measured at each well prior to sample collection (Table 13).

Table 13. Water quality field parameters—Weiser Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Field Measurements			
			Water Temperature (°C)	pH[a]	Specific Conductivity (μS/cm)	Dissolved Oxygen (mg/L)
2268	42	5/14/2014	13.5	7.7	1160	5.37
2269	75	5/12/2014	14.1	7.93	603	1.75
2270	59	5/12/2014	14.7	7.81	714	2.54
2271	36	5/14/2014	12.9	7.7	735	4.82
2272	30	5/14/2014	13.3	7.73	1140	9.78
2273	40	5/13/2014	16.3	*8.54*	229	0.05
2274	70	5/12/2014	14.8	7.8	701	3.21
2275	36	5/12/2014	15.2	7.73	635	3.21
2276	47.8	5/12/2014	14.2	7.84	720	1.15
2277	40	5/14/2014	14.7	8.12	645	0.01
2278	104	5/12/2014	13.4	7.43	590	2.38
2279	52	5/13/2014	13.8	7.81	703	3.18
2280	38	5/12/2014	14.9	7.8	685	2.62
2281	50	5/13/2014	13.9	7.64	684	4.77
2282	34	5/13/2014	14.8	7.96	483	7.21
2283	37	5/12/2014	13	7.76	621	0.2
2284	36	5/12/2014	13.8	7.77	571	1.67
2285	60	5/14/2014	13.6	7.82	1020	0.06
2286	50	5/14/2014	14.2	7.74	1450	0.01
2287	124	5/13/2014	17	7.24	1240	0.02
2288	90	5/12/2014	24.4	7.83	629	0.02
2289	33	5/14/2014	13.5	7.95	980	0.03
2290	50	5/12/2014	14.3	7.96	683	1.87
2291	30	5/13/2014	13	7.74	614	0.04
2292	38	5/13/2014	15	7.77	538	6.8
2293	28	5/13/2014	12.6	7.68	734	0.03
2294	41	5/13/2014	13.3	7.62	650	3.48
2295	50	5/13/2014	14.5	8.13	160	8.54
2296	33	5/14/2014	13.7	7.77	1820	6.08
2297	47	5/13/2014	14.1	7.65	980	8.4
2298	60	5/12/2014	14.1	7.79	415	2.56
2299	31	5/14/2014	12.6	7.49	1000	4.07
2300	60	5/13/2014	13.5	7.62	1060	8.09
2301	50	5/13/2014	15.1	7.77	940	8.97
2302	55	5/13/2014	12.7	7.77	715	1.67
2303	221	5/12/2014	14.4	7.55	1500	4.49

DEQ Site ID	Well Depth (feet)	Sample Date	Field Measurements			
			Water Temperature (°C)	pH[a]	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
2305	79	5/13/2014	13.9	7.43	726	2.86

[a] Contaminant with a National Secondary Drinking Water Regulation standard. Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard exceeded. These regulations are applicable for public water systems only but are recommended limits and can be used to evaluate water quality in private wells. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Samples collected from each well were analyzed for nitrate, nitrite, total coliform, and *E. coli* (Table 14; Figure 12). Nitrogen isotope samples were collected at each sampling location and frozen and stored at DEQ pending nitrate analysis. After DEQ received nitrate analysis results, those nitrogen isotope samples from wells with nitrate concentrations greater than 5 mg/L were sent to the University of Arizona Environmental Isotope Geosciences Laboratory in Tucson, Arizona, for nitrogen isotope analysis.

Table 14. Inorganic and bacteria results—Weiser Nitrate Priority Area Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Nutrient Concentrations			Bacteria[b]	
			Nitrate[a]	Nitrite[a]	$\delta^{15}N$	Total Coliform	*E. coli*
			(mg/L)		(‰)	(MPN/100 mL)	
Primary or Secondary Standard:			***10***	***1***	***NA***	***1 cfu/100 mL***	***<1 cfu/100 mL***
2268	42	5/14/2014	**12.3**	<0.30	6.5	<1	<1
2269	75	5/12/2014	9.06	<0.30	2.3	<1	<1
2270	59	5/12/2014	**12.3**	<0.30	3.6	<1	<1
2271	36	5/14/2014	**13.6**	<0.30	4.7	<1	<1
2272	30	5/14/2014	<0.18	<0.30	—	<1	<1
2273	40	5/13/2014	<0.18	<0.30	—	<1	<1
2274	70	5/12/2014	3.01	<0.30	—	<1	<1
2275	36	5/12/2014	**11.5**	<0.30	3.2	<1	<1
2276	47.8	5/12/2014	**12.5**	<0.30	3.6	<1	<1
2277	40	5/14/2014	<0.18	<0.30	—	<1	<1
2278	104	5/12/2014	3.64	<0.30	—	<1	<1
2279	52	5/13/2014	**14.2**	<0.30	3.3	<1	<1
2280	38	5/12/2014	**13.9**	<0.30	4.3	<1	<1
2281	50	5/13/2014	**12.2**	<0.30	2.6	<1	<1
2282	34	5/13/2014	1.95	<0.30	—	1.0	<1
2283	37	5/12/2014	6.23	<0.30	6.5	<1	<1
2284	36	5/12/2014	8.14	<0.30	5	<1	<1
2285	60	5/14/2014	**11.1**	<0.30	4.4	1.0	<1
2286	50	5/14/2014	**10.4**	<0.30	9.9	<1	<1
2287	124	5/13/2014	<0.18	<0.30	—	<1	<1
2288	90	5/12/2014	<0.18	<0.30	—	<1	<1
2289	33	5/14/2014	**11.1**	<0.30	8.7	<1	<1
2290	50	5/12/2014	1.69	<0.30	—	<1	<1
2291	30	5/13/2014	5.7	<0.30	7.4	<1	<1
2292	38	5/13/2014	0.877	<0.30	—	1.0	<1
2293	28	5/13/2014	7.54	<0.30	7.2	<1	<1
2294	41	5/13/2014	6.32	<0.30	4.7	2.0	<1
2295	50	5/13/2014	0.79	<0.30	—	8.5	<1
2296	33	5/14/2014	**22.9**	<0.30	4.5	<1	<1
2297	47	5/13/2014	**13.7**	<0.30	4.6	<1	<1
2298	60	5/12/2014	1.42	<0.30	—	<1	<1
2299	31	5/14/2014	**10.2**	<0.30	6.1	<1	<1
2300	60	5/13/2014	5.92	<0.30	11.8	18.5	<1
2301	50	5/13/2014	**16.6**	<0.30	3.3	<1	<1
2302	55	5/13/2014	8.58	<0.30	6.6	<1	<1
2303	221	5/12/2014	**18.4**	<0.30	3.2	4.1	<1
2305	79	5/13/2014	2.48	<0.30	—	<1	<1

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. (—) = data are unavailable or were not analyzed

[a] Contaminant with a National Primary Drinking Water Regulation standard.

[b] Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded numbers) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

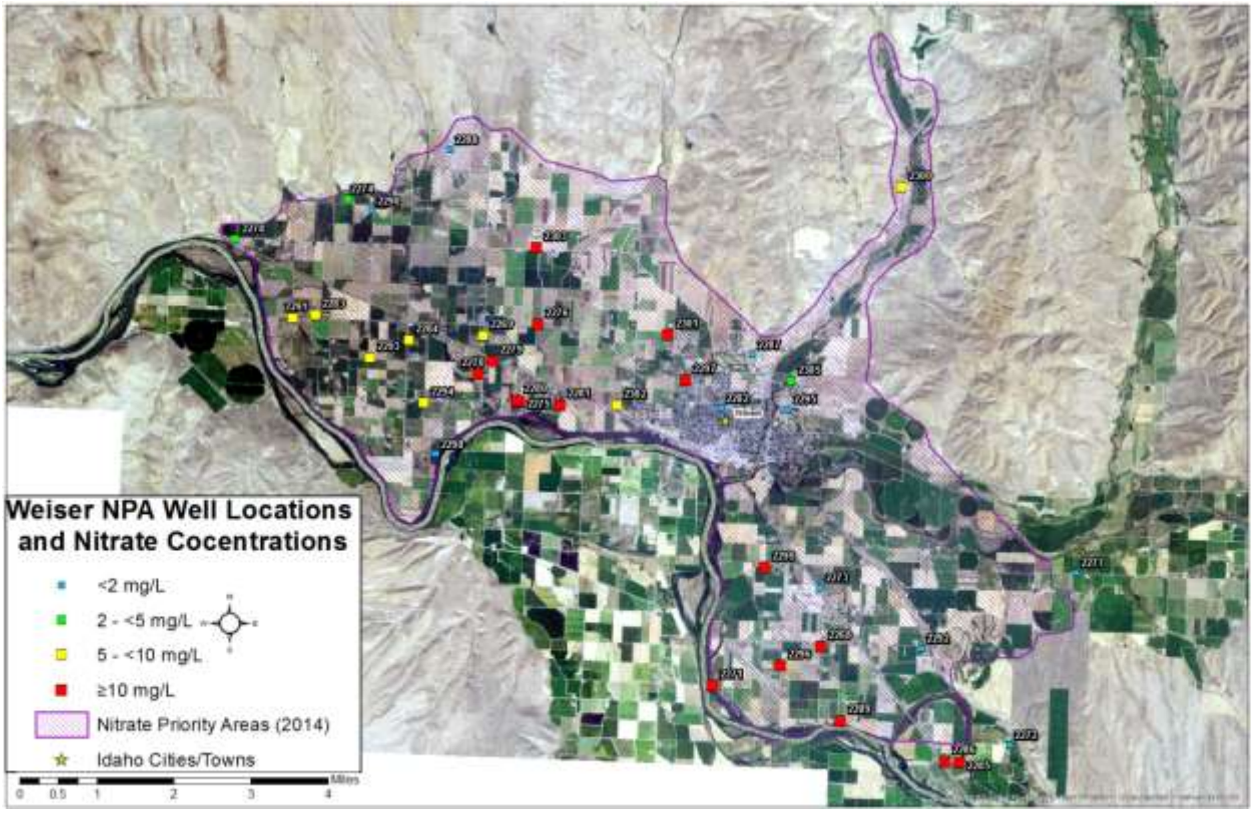


Figure 12. Sample locations and nitrate concentrations—Weiser Nitrate Priority Area Ground Water Monitoring Project.

Nitrate Results

The reported nitrate concentrations ranged from <0.18 mg/L to 22.9 mg/L; 24 of the 37 wells sampled had nitrate concentration of 5 mg/L or greater. The nitrate MCL of 10 mg/L was exceeded in 16 samples (2268, 2270, 2271, 2301, 2275, 2276, 2279, 2280, 2281, 2303, 2285, 2286, 2289, 2296, 2297, and 2299). The spatial distribution of nitrate concentrations is shown in Figure 12.

Bacteria Results

In total, 7 of the 37 wells sampled were positive for total coliform (TC) bacteria (2282, 2303, 2285, 2292, 2294, 2295, and 2300). The reported positive TC concentrations ranged from 1.0 MPN/100 mL to 18.5 MPN/100 mL. None of the 37 wells tested positive for *E. coli*.

Nitrogen Isotope Results

Nitrogen isotope ratios, denoted as $\delta^{15}N$, can be helpful in determining the potential sources of nitrate in the ground water. Nitrogen isotope ratios were determined for all samples with nitrate concentrations greater than or equal to 5 mg/L (Table 14). Nitrogen from human or animal waste and fertilizer sources has distinguishable $\delta^{15}N$ signatures. Typical $\delta^{15}N$ values for various nitrogen sources are listed in Table 4.

The $\delta^{15}N$ ratio results from this project ranged from 2.3‰ to 11.8‰. Eight wells (2269, 2270, 2301, 2275, 2276, 2279, 2281, and 2303) had $\delta^{15}N$ ratios at or below 4‰, indicating the source of nitrates in the ground water is most likely from commercial fertilizer (Seiler 1996). Fourteen wells (2268, 2271, 2280, 2302, 2283, 2284, 2285, 2289, 2291, 2293, 2294, 2296, 2297 and 2299) had $\delta^{15}N$ ratios between 4‰ and 9‰, indicating the source of nitrates in the ground water is most likely from organic nitrogen in soil or a mixed nitrogen source (Seiler 1996). Two wells (2286 and 2300) had $\delta^{15}N$ ratios of greater than 9‰, indicating the source of nitrates in the ground water is most likely from animal or human waste (Seiler 1996).

2.1.5.3 Conclusions

The criterion for an NPA is at least 25% of the wells sampled within the area meet or exceed 5 mg/L nitrate. This value is half the MCL of 10 mg/L. In this project, 24 of the 37 wells sampled (65%) had nitrate values ≥5 mg/L. The nitrate MCL of 10 mg/L was exceeded in 16 of these samples. Of the 32 wells sampled in the NPA (stratum 1), 21 wells (67%) had nitrate concentrations greater than 5 mg/L, 13 of which were above the MCL. Of the 5 wells sampled outside the NPA, 3 wells (60%) had concentrations above 5 mg/L, with all 3 above the MCL.

Positive detections of total coliform bacteria were found in 7 wells, 2 of which were wells with nitrate concentrations above the MCL for nitrate.

The $\delta^{15}N$ ratios suggest the primary source of nitrates in the Weiser NPA is a mixture of nitrate sources, including fertilizer and organic sources such as crop decay (e.g., legume crop plow down) and/or organic nitrogen in the soil. Nitrogen sources were varied throughout the project: 2 wells had a nitrogen isotopic signature consistent with an animal or human waste source, 8 wells had a nitrogen isotopic signature consistent with commercial fertilizer, and 14 wells had a nitrogen isotopic signature consistent with an organic or mixed nitrogen source.

The primary land uses in the Weiser NPA are agricultural and residential. The primary agricultural use is irrigated cropland; however, several cattle operations are upgradient of the Weiser NPA.

2.1.5.4 Recommendations

DEQ recommends that property owners with private domestic drinking water wells sample their well—prior to any water treatment system and as close to the well as possible—on an annual basis. Southwest District Health can provide Washington County property owners with information and guidance on well sampling and result interpretation.

In addition, property owners may benefit from education on the use of commercial fertilizers and pesticides on their lawns and gardens and education on proper maintenance of their wells and septic systems.

The Weiser River Water Advisory Group is implementing projects in the area of the Weiser River to reduce sediment. Some of these activities include working with the agricultural community to reduce over irrigation of fields. This activity may also help reduce nitrate concentration in ground water through a reduction in the downward movement or leaching of nitrogen.

DEQ has assisted Washington County in developing and implementing ground water quality improvement and drinking water source protection plans. These plans include outreach activities for private well owners and agricultural operators aimed at reducing source water contamination, including activities to reduce nitrate contamination. Ground water quality management plans are available at *www.deq.idaho.gov/water-quality/ground-water/management-plans*.

DEQ will notify ISDA of water quality concerns in this area and will cooperate in educating the agricultural community and assisting in implementing BMPs and NMPs in the area in and around the Weiser NPA, if needed.

2.2 Idaho Falls Region

One ground water quality monitoring project was conducted in the Idaho Falls region in 2014 using public funds.

2.2.1 Eastern Snake River Plain Regional Ground Water Monitoring Project

2.2.1.1 Purpose and Background

The Idaho Falls DEQ region has been divided into subareas based on land use and hydrogeologic boundaries to allow for identification/detection of impacts or changes to ambient ground water quality. The process for identifying these subareas is described in *Regional Ground Water Monitoring Network Design, Idaho Falls Regional Office* (DEQ 2013c). Definitions for the specific subareas are summarized in *Idaho Falls Regional Office Ambient Ground Water Monitoring Plan Development: Defining Subareas* (DEQ 2013a). Currently the Teton Basin/Ashton, Eastern Snake River Plain, and Mud Lake subareas have been defined. Sampling for the Eastern Snake River Plain (ESRP) subarea was completed in 2014. Sampling is planned for the Mud Lake subarea in 2015. With the conclusion of the Mud Lake sampling, a more complete interpretive technical report is planned.

The ESRP subarea covers 744 square miles of eastern Idaho, consisting primarily of the relatively low lands adjacent to the Henrys Fork and South Fork of the Snake River, as well as the lower extent of the Teton River drainages along this eastern margin of the Eastern Snake River Plain. The regional geology for the ESRP aquifer is dominated by basalts, interbedded sediments, and rhyolites. Basalts dominate toward the central portions of the plain where they are as much as several thousand feet thick. Towards the margins of the ESRP, sediments and permeable rhyolites can be significant. Transmissivity and aquifer thickness are again greatest towards the center of the ESRP and tend to be less towards the margins. The Eastern Snake River Plain aquifer tends to respond as unconfined towards the center and as confined toward the margins, reflecting the larger proportion of sediments (Stearns et al. 1938; Whitehead 1992). Major sources of recharge are downward percolation of precipitation and snowmelt; runoff from the surrounding uplands; stream flow losses, particularly from the Henrys Fork and South Fork of the Snake River; and direct infiltration of surface water diverted for irrigation (Graham and Campbell 1981).

2.2.1.2 Methods and Results

Sample locations were selected from domestic wells with available well logs. Selection favored more recent wells with complete information concerning well construction, well-bore seals, and lithologic descriptions suggesting that ground water sampled would represent the shallow-most aquifer zone. The number of sample sites needed to adequately represent the area of interest was based on a statistical process developed by Dr. Kirk Steinhorst of the University of Idaho (Steinhorst 2011). Steinhorst's statistical process was used to develop a sample design strategy that would estimate the number of samples needed to represent the mean nitrate concentration for the region and adequately distinguish changes in nitrate status from one sampling period to the next within a 90% confidence interval with a probability value of 0.80. Ground water monitoring data from IDWR Statewide Monitoring Network (IDWR SMN) and the ISDA regional monitoring project 840 were utilized in this strategy. A total of 236 nitrite plus nitrate results were available, with a mean of 1.27 mg/L and median of 0.92 mg/L after outliers (results exceeding 1.5 times the interquartile range) were removed. A goal of 25 to 27 sample sites was established.

Potential sample sites were selected from randomly identified and ordered 1-mile sections completely within the 744-square-mile study area. Sections that included IDWR SMN or ISDA sites were excluded. Suitable wells within each section were ordered by date of construction and completion depth. Forty sections and potential wells were identified and efforts to identify and contact the current well owner for obtaining permission were made. Eventually 26 randomly selected wells were sampled. The resulting well selection process yielded suitable sample locations randomly distributed across the subarea. Results from these randomly selected wells can statistically represent the subarea and can be combined with results from other sampling networks to make inferences concerning population values. An additional site not within the ESRP subarea was also included by request from a private well owner who attended a DEQ source water protection workshop. A nitrate test strip screening of his well water indicated elevated nitrates, and ultimately this well was included with the regional sampling.

Sites were sampled October–December 2014 following the Idaho Falls Regional Office QAPP for regional nitrate monitoring (DEQ 2011d) and the FSP for Eastern Snake River Plain aquifer regional monitoring (DEQ 2014b). Duplicate samples were collected for two locations and one field blank was collected during the sampling period.

For each sample site field parameters were monitored until temperature, specific conductance, pH, and dissolved oxygen stabilized, indicating that the well had been purged as per procedures. Samples were analyzed by Idaho Bureau of Laboratories (IBL) in Boise for calcium, sodium, magnesium, potassium, chloride, fluoride, sulfate, bromide, total alkalinity, and nitrite plus nitrate. Samples were analyzed for ammonia for sites where the dissolved oxygen was low (<~ 5 mg/L). Wells with positive bromide detections were also analyzed for boron. Additionally, analysis for arsenic was completed for one sample site due to its proximity to an area with elevated arsenic concentrations in ground water. Samples for total coliform and *E. coli* bacteria were analyzed by IAS Environmental in Pocatello. After receiving the major ion chemistry and nutrient results, samples for stable isotope analysis were submitted to Northern Arizona University–Colorado Plateau Stable Isotope Laboratory for stable isotopes of nitrogen and oxygen in nitrate ($\delta^{15}N_{nitrate}$, $\delta^{18}O_{nitrate}$) and University for Arizona for stable isotopes of oxygen and hydrogen in water ($\delta^{18}O$ and $\delta^{2}H$) and nitrogen stable isotopes ($\delta^{2}N$) for sites with detectable concentrations of ammonia. Samples were also submitted to Idaho State University Environmental Monitoring Laboratory for environmental-level tritium analyses.

Results for field parameters are presented in Table 15. Well depth, major ion chemistry, nutrient, and bacteria results are presented in Table 16. Stable isotope results are presented in Table 17. Bromide, boron, and arsenic results are presented in Table 18. Duplicate samples were analyzed for major ion chemistry, nutrients, and stable isotopes, and one set of field blanks was analyzed for major ion chemistry and nutrients.

Major ion chemistry provides a picture of the overall relative character of ground water, including mixing from different sources and changes in ground water chemistry from processes such as dissolution of the aquifer matrix, infiltration, and impacts from contamination sources. Major ion chemistry along with field parameters can also provide clues to ongoing chemical processes and indications of the favored chemical forms for nitrogen in ground water. Bacterial analyses aid in identifying potential impacts or influences at the wellhead or sample point. Relative chemical relationships can provide indications of major recharge sources. Stable isotope results can also aid in understanding the possible ongoing thermodynamic or biochemical processes within the system. Taken together, these indicators may help identify sources of nitrates to the ground water system. ESRP subarea sample collection included analysis for tritium as a tool to gage the age of recharge. Tritium results were not available at the time this report was written and published. Discussion of tritium results will be presented in a later comprehensive technical report.

Figure 13 presents sample locations and nitrate results for the ESRP subarea. Ground water elevations indicate a southwesterly direction of flow generally paralleling the Henrys Fork and South Fork of the Snake River.

Table 15. Water quality field parameters—Eastern Snake River Plain Regional Ground Water Monitoring Project.

Project Well Name	DEQ Site ID	Sample Date	Field Measurements			
			Water Temperature (°C)	Specific Conductivity (μS/cm)	pH[a]	Dissolved Oxygen (mg/L)
ESRP-01	2379	10/22/2014	14.34	157	6.97	5.57
ESRP-02	2381	10/22/2014	12.95	205	7.67	5.68
ESRP-03	2382	10/22/2014	10.98	305	7.29	3.70
ESRP-04	2380	10/22/2014	10.00	475	7.46	4.80
ESRP-05	2383	10/22/2014	12.12	469	7.41	7.36
ESRP-06	2384	10/22/2014	12.40	497	7.45	7.98
ESRP-07	2385	10/22/2014	13.39	514	7.49	5.76
ESRP-08	2386	10/22/2014	12.80	378	7.50	8.10
ESRP-09	2387	10/29/2014	14.68	236	7.77	6.11
ESRP-10	2388	10/29/2014	11.65	401	7.75	0.84
ESRP-11	2389	10/29/2014	8.87	424	7.72	6.08
ESRP-12	2390	10/29/2014	13.20	329	7.78	6.06
ESRP-13	2391	10/29/2014	14.95	344	7.84	5.45
ESRP-14	2392	11/05/2014	13.89	350	7.59	7.13
ESRP-15	2393	11/05/2014	12.27	255	7.66	6.69
ESRP-16	2394	11/05/2014	9.92	445	8.10	0.78
ESRP-17	2395	11/05/2014	12.78	424	7.55	2.57
ESRP-18	2396	11/05/2014	12.26	424	7.75	6.58
ESRP-19	2397	11/05/2014	12.78	521	7.47	6.68
ESRP-20	2398	11/12/2014	16.80	707	7.59	6.13
ESRP-21	2399	11/19/2014	12.63	544	7.36	7.71
ESRP-22	2400	11/19/2014	10.18	404	7.65	6.38
ESRP-23	2403	12/03/2014	8.45	1377	7.62	0.09
ESRP-24	2404	12/03/2014	9.48	497	7.79	6.69
ESRP-25	2401	12/03/2014	10.91	394	7.76	6.37
ESRP-26	2402	12/03/2014	10.13	200	7.24	5.49
ESRP-30	2405	10/23/2014	12.50	379	7.73	7.70

[a] Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems and are used with private wells to evaluate water quality.

Table 16. Major ion, nutrient, and bacteria results—Eastern Snake River Plain Regional Ground Water Monitoring Project.

Project Well Name	DEQ Site ID	Well Depth (feet)	Casing Depth (feet)	Sample Date	Major Ion Concentrations (mg/L)								Nutrient Concentrations		Bacteria[c]	
					Calc-ium	Magnes-ium	Sodium	Potas-sium	Chlo-ride[b]	Fluo-ride[a]	Sulfate[b]	Alkalinity (as CaCO3)	Nitrite plus Nitrate[a]	Am-monia	Total Coliform	*E. coli*
					(mg/L)										(MPN/100 mL)	
Standard:					***NA***	***NA***	***NA***	***NA***	***250***	***4***	***250***	***NA***	***10***	***NA***	***1 cfu/ 100 mL[c]***	***<1 cfu/ 100 mL[c]***
ESRP-01	2379	160	122	10/22/2014	15	4.6	13	2.6	4.23	1.42	4.03	69	0.74	<0.010	<1.0	<1.0
ESRP-02	2381	150	—	10/22/2014	22	5.8	14	2.9	4.94	1.58	9.11	82	1.9	0.015	<1.0	<1.0
ESRP-03	2382	118	118	10/22/2014	40	12	9.4	3	3.15	0.695	6.03	156	0.94	<0.010	2419.2	<1.0
ESRP-04	2380	48	48	10/22/2014	68	16	15	2.4	16.7	0.344	59.8	178	0.61	0.016	3.0	<1.0
ESRP-05	2383	243	196	10/22/2014	68	18	12	2.9	10	0.348	40.7	204	1.6	—	<1.0	<1.0
ESRP-06	2384	195	195	10/22/2014	66	21	17	4.5	13.9	0.371	42.1	220	2.5	—	<1.0	<1.0
ESRP-07	2385	220	178	10/22/2014	71	19	15	4	12.7	0.406	36.7	224	1.7	<0.010	<1.0	<1.0
ESRP-08	2386	222	133	10/22/2014	53	14	11	2.5	9.58	0.34	36.7	158	1.4	—	4.1	<1.0
ESRP-09	2387	122	110	10/29/2014	32	5.2	13	3.4	5.25	1.56	4.63	110	1.6	—	<1.0	<1.0
ESRP-10	2388	142	135	10/29/2014	55	14	14	2.3	14.5	0.36	51.8	152	0.044	0.037	1.0	<1.0
ESRP-11	2389	58	58	10/29/2014	58	14	15	2.2	12.3	0.349	53.7	166	0.54	—	<1.0	<1.0
ESRP-12	2390	80	—	10/29/2014	48	11	10	1.8	6.77	0.346	33.7	141	0.17	—	<1.0	<1.0
ESRP-13	2391	138	—	10/29/2014	49	12	9.2	1.8	11.4	0.321	45.3	129	0.15	—	<1.0	<1.0
ESRP-14	2392	281	225	11/5/2014	33	13	30	2.9	11.2	1.31	15.8	160	2.7	—	1.0	<1.0
ESRP-15	2393	243	243	11/5/2014	28	9.2	16	2.7	8.38	1.21	6.42	119	1.1	—	<1.0	<1.0
ESRP-16	2394	78	78	11/5/2014	67	18	12	3.3	14	0.394	51.5	193	1.1	<0.010	1.0	<1.0
ESRP-17	2395	38	38	11/5/2014	62	14	12	3	10.4	0.382	42.7	182	0.63	0.014	<1.0	<1.0
ESRP-18	2396	203	195	11/5/2014	60	16	12	2.6	10.6	0.322	41.3	182	1.1	—	<1.0	<1.0
ESRP-19	2397	180	180	11/0514	69	20	21	4.9	15.1	0.28	36.9	236	1.9	—	<1.0	<1.0
ESRP-20	2398	150	150	11/12/2014	70	23	44	8.4	106	0.245	54.2	171	2.3	<0.010	<1.0	<1.0
ESRP-21	2399	140	—	11/19/2014	80	19	20	4.1	19	0.269	38.8	242	1.8	<0.010	<1.0	<1.0
ESRP-22	2400	100	99	11/19/2014	61	14	12	1.9	10.1	0.324	40.1	176	0.15	<0.010	<1.0	<1.0
ESRP-23	2403	35	—	12/3/2014	180	44	54	5.9	143	0.618	315	249	0.004	0.27	1.0	<1.0
ESRP-24	2404	325	245	12/3/2014	59	19	18	3.2	19.1	0.432	50.1	186	1.6	—	<1.0	<1.0

Project Well Name	DEQ Site ID	Well Depth (feet)	Casing Depth (feet)	Sample Date	Major Ion Concentrations (mg/L)								Nutrient Concentrations		Bacteria[c]	
					Calc-ium	Magnes-ium	Sodium	Potas-sium	Chlo-ride[b]	Fluo-ride[a]	Sulfate[b]	Alkalinity (as CaCO3)	Nitrite plus Nitrate[a]	Am-monia	Total Coliform	*E. coli*
					(mg/L)										(MPN/100 mL)	
Standard:					***NA***	***NA***	***NA***	***NA***	***250***	***4***	***250***	***NA***	***10***	***NA***	***1 cfu/ 100 mL[c]***	***<1 cfu/ 100 mL[c]***
ESRP-25	2401	138	138	12/3/2014	55	13	9.8	2.2	9.45	0.361	36.8	161	0.65	—	<1.0	<1.0
ESRP-26	2402	120	83	12/3/2014	18	7.2	13	3.1	4.54	1.51	4.31	83	1.1	<0.010	<1.0	<1.0
ESRP-30	2405		—	10/23/2014	43	15	19	3.1	13.8	0.837	33.8	124	9.2	—	<1.0	<1.0

Notes: (—) = data are unavailable or were not analyzed

[a] Contaminant with a National Primary Drinking Water Regulation standard.

[b] Contaminant with a National Secondary Drinking Water Regulation standard.

[c] Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded cells) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

Table 17. Stable isotope analytical results—Eastern Snake River Plain Ground Water Monitoring Project.

Project Well Name	DEQ Site ID	Sample Date	NAU CPSIL[a]		University of Arizona		
			$\delta^{15}N_{nitrate}$ (‰)	$\delta^{18}O_{nitrate}$ (‰ VSMOW)	$\delta^{15}N$ (‰)	$\delta^{18}O$ (‰ VSMOW)	$\delta^{2}H$ (‰ VSMOW)
ESRP-01	2379	10/22/14	1.58	-6.64	—	-17.2	-130
ESRP-02	2381	10/22/14	3.54	-4.63	4.6	-17.4	-131
ESRP-03	2382	10/22/14	5.82	-7.78	6.6	-17.9	-135
ESRP-04	2380	10/22/14	3.39	-7.55	4.5	-17.7	-133
ESRP-05	2383	10/22/14	2.79	-8.08	—	-17.5	-132
ESRP-06	2384	10/22/14	3.25	-7.15	—	-17.3	-131
ESRP-07	2385	10/22/14	3.97	-7.43	—	-17.3	-131
ESRP-08	2386	10/22/14	1.84	-8.82	—	-17.4	-131
ESRP-09	2387	10/29/14	5.89	-4.83	—	-17.2	-130
ESRP-10	2388	10/29/14	4.01	-11.09	5.8	-17.7	-134
ESRP-11	2389	10/29/14	3.65	-8.82	—	-17.7	-133
ESRP-12	2390	10/29/14	4.91	-10.52	—	-17.6	-133
ESRP-13	2391	10/29/14	4.81	-9.26	—	-17.5	-131
ESRP-14	2392	11/05/14	4.36	-4.28	—	-17.3	-129
ESRP-15	2393	11/05/14	5.57	-4.87	—	-17.5	-131
ESRP-16	2394	11/05/14	7.02	-4.57	7.8	-17.6	-133
ESRP-17	2395	11/05/14	6.20	-6.77	6.6	-17.6	-132
ESRP-18	2396	11/05/14	3.75	-6.88	—	-17.6	-132
ESRP-19	2397	11/0514	5.08	-6.32	—	-17.3	-130
ESRP-20	2398	11/12/14	5.76	-7.61	—	-17.5	-133
ESRP-21	2399	11/19/14	6.03	-5.87	—	-17.4	-131
ESRP-22	2400	11/19/14	5.25	-9.89	—	-17.6	-132
ESRP-23	2403	12/03/14	—[b]	—[b]	5.1	-15.6	-124
ESRP-24	2404	12/03/14	4.23	-6.17	—	-17.8	-133
ESRP-25	2401	12/03/14	4.48	-7.60	—	-17.7	-132
ESRP-26	2402	12/03/14	2.17	-6.38	—	-17.2	-129
ESRP-30	2405	10/23/14	1.11	-7.44	—	-17.5	-132

Note: Stable isotope analytical results are presented as delta values (δ) reported as parts per thousand (identified as per mill or ‰) compared to a standard. For $\delta^{15}N$ and $\delta^{15}N_{nitrate}$, delta values represent $^{15}N/^{14}N$ of the sample compared to $^{15}N/^{14}N$ for nitrogen in air, reported as $\delta^{15}N_{air}$. Standards for $\delta^{18}O$, $\delta^{18}O_{nitrate}$, and $\delta^{2}H$ are Vienna Standard Mean Ocean Water (VSMOW).
(—) = data are unavailable or were not analyzed
[a] Northern Arizona University–Colorado Plateau Stable Isotope Laboratory
[b] Insufficient nitrate in sample for analysis.

Table 18. Bromide, boron, and arsenic results—Eastern Snake River Plain subarea regional monitoring.

Project Well Name	DEQ Site ID	Sample Date	Bromide[a] (mg/L)	Boron[b] (mg/L)	Arsenic[c] (µg/L)
Standard			***NA***	***NA***	***10***
ESRP-01	2379	10/22/14	<0.80	—	—
ESRP-02	2381	10/22/14	<0.80	—	—
ESRP-03	2382	10/22/14	<0.80	—	—
ESRP-04	2380	10/22/14	<0.80	—	—
ESRP-05	2383	10/22/14	<0.80	—	—
ESRP-06	2384	10/22/14	0.14	0.075	—
ESRP-07	2385	10/22/14	<0.80	—	—
ESRP-08	2386	10/22/14	<0.80	—	—
ESRP-09	2387	10/29/14	<0.80	—	—
ESRP-10	2388	10/29/14	<0.80	—	—
ESRP-11	2389	10/29/14	<0.80	—	—
ESRP-12	2390	10/29/14	<0.80	—	—
ESRP-13	2391	10/29/14	<0.80	—	—
ESRP-14	2392	11/05/14	0.72	0.160	—
ESRP-15	2393	11/05/14	<0.80	—	—
ESRP-16	2394	11/05/14	<0.80	—	—
ESRP-17	2395	11/05/14	<0.80	—	—
ESRP-18	2396	11/05/14	<0.80	—	—
ESRP-19	2397	11/05/14	0.98	0.069	—
ESRP-20	2398	11/12/14	0.16	0.095	—
ESRP-21	2399	11/19/14	<0.80	—	—
ESRP-22	2400	11/19/14	<0.80	—	—
ESRP-23	2403	12/03/14	0.35	—	3.8
ESRP-24	2404	12/03/14	<0.80	—	—
ESRP-25	2401	12/03/14	<0.80	—	—
ESRP-26	2402	12/03/14	<0.80	—	—
ESRP-30	2405	10/23/14	<0.80	—	—

Note: (—) = data were not analyzed.
[a] IBL has a standard minimum reporting level of 0.80 mg/L with the EPA 300.0 method. IBL was able to achieve a minimum detection level of 0.034 mg/L for samples with positive detections.
[b] After initial laboratory reporting, boron analysis was requested for samples from sites ESRP-06, -14, -19, and -20.
[c] Contaminant with a National Primary Drinking Water Regulation standard.

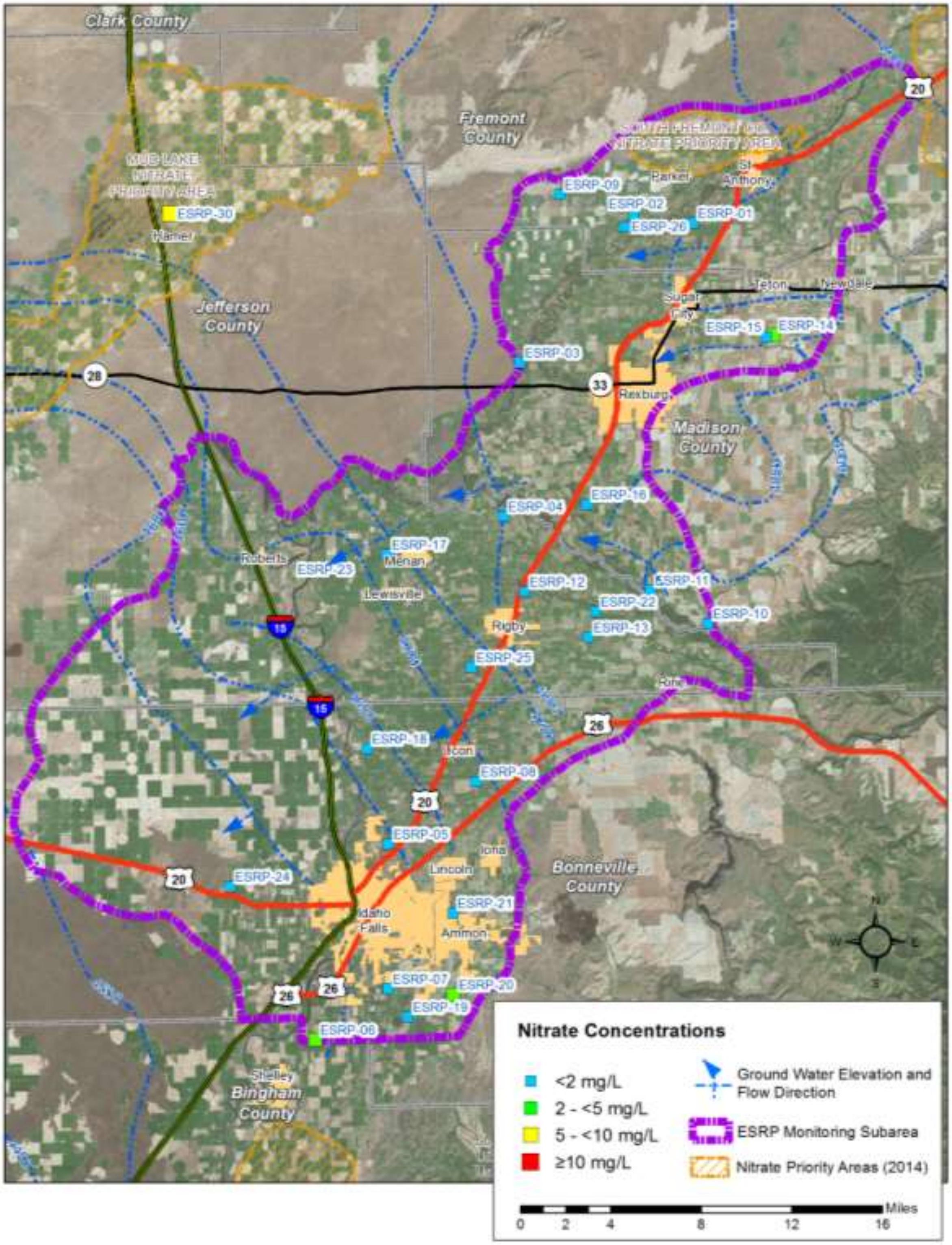


Figure 13. Nitrate concentrations and ground water flow direction—Eastern Snake River Plain Regional Ground Water Monitoring.

General Ground Water Chemistry

Ground water in the ESRP subarea is primarily a calcium-bicarbonate bicarbonate water with generally low but increasing relative proportion of sulfate. The Piper trilinear water chemistry plot (Figure 14) provides some interesting insights into the variation in ground water chemistry for this portion of the ESRP aquifer: (1) major ion chemistry for this region can be explained largely by mixing between ground water from two general recharge sources, the Henrys Fork of the Snake River and the South Fork of the Snake River, and (2) a general increase in the relative proportion of sulfate occurs with movement down the aquifer flowpath. The cation portion of the Piper diagram suggests a general increase in the proportion of magnesium as Henrys Fork and South Fork ground waters mix. The anion portion of the diagram suggests a mixing of greater relative sulfate waters from the South Fork of the Snake River with Henrys Fork waters. Site ESRP-03 potentially represents an endpoint, reflecting chemistry of Henrys Fork river water. Sites ESRP-20 and 23 both have significantly greater proportions of chloride or sulfate and chloride, indicative of some local influence. Site ESRP-30 plots similar to the sites representing a mixture of sources. Future sampling should include samples of surface water that could potentially represent major recharge sources, which would allow a better understanding of mixing from different recharge sources.

Relative concentrations of major ions can provide clues to the potential sources of nitrates to ground water. Figure 15 presents the relationship of sulfate to chloride. This relationship can provide a basis for distinguishing between some sites, with a common observation of a higher sulfate/chloride value reflecting an influence from sulfate-based fertilizers and a low ratio (much less than 1) reflecting a waste-related impact. Such interpretations must be supported by additional data. Relationships may also aid in distinguishing between recharge sources. Figure 15 reflects grouping apparent from the Piper diagram (Figure 14), with the sites identified as reflecting recharge from the Henrys Fork (ESRP-01, 02, 03, 09, 14, and 15) plotting within a relatively close group with a sulfate/chloride ratio less than 1. Sites ESRP-20 and 23 plotted significantly different from all other sites. The remaining sites, representing the South Fork and the mixed groups A and B, plotted relatively close together.

Figure 16 presents the relationship of relative sulfate/chloride to nitrite plus nitrate. Again, the Henrys Fork grouping can be identified, with two sites plotting with either a slightly higher relative sulfate (ESRP-02) or a higher nitrite plus nitrate (ESRP-14). The sites identified as mixed sources A and B plotted in overlapping fields and the South Fork sites plotting in a group, possibly reflecting a mixing of those sources. Several other sites distinguished by nitrate concentrations or by distinct locations on the Piper are also distinct in Figure 16. Site ESRP-20 plots with the lowest ratio, <0.5, while ESRP-12 plots with the highest ratio. ESRP-30, with a nitrate result of 9.2, had a ratio of 2.45. ESRP-23 plotted with a ratio of 2.2. This site had very low oxygen measured in the field and the highest result for ammonia (0.27 mg/L, with nitrite plus nitrate at 0.004 mg/L).

In general, some sites were distinguished by their sulfate/chloride ratio from the groups characterized by the Piper diagram (ESRP 02, 12, and 14) and some were distinct from their grouping by their nitrate concentrations (ESRP-06, 14, and 20). Others remained distinct by the combination of nitrate levels and sulfate/chloride ratios (ESRP-03, 20, 23, and 30). For the ESRP subarea, it's possible that the natural ratio of sulfate/chloride is relatively low (<1); thus, a low sulfate/chloride ratio alone may not be indicative of a waste signature. A higher ratio may, however, support influence from a sulfate source, as in the case of ESRP-30 (nitrate of 9.2 mg/L and sulfate/chloride ratio of 2.44). Other sites with nitrates greater than background and a sulfate/chloride ratio >2 may be indicative of an inorganic nitrate source (ESRP-06 and 14).

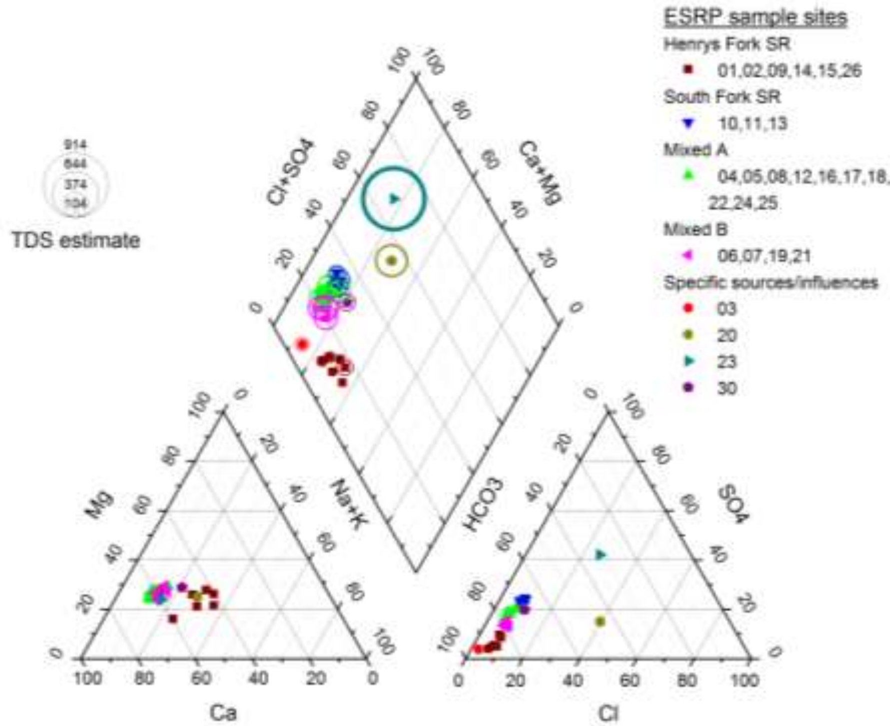


Figure 14. Piper diagram for Eastern Snake River Plain regional monitoring subarea.

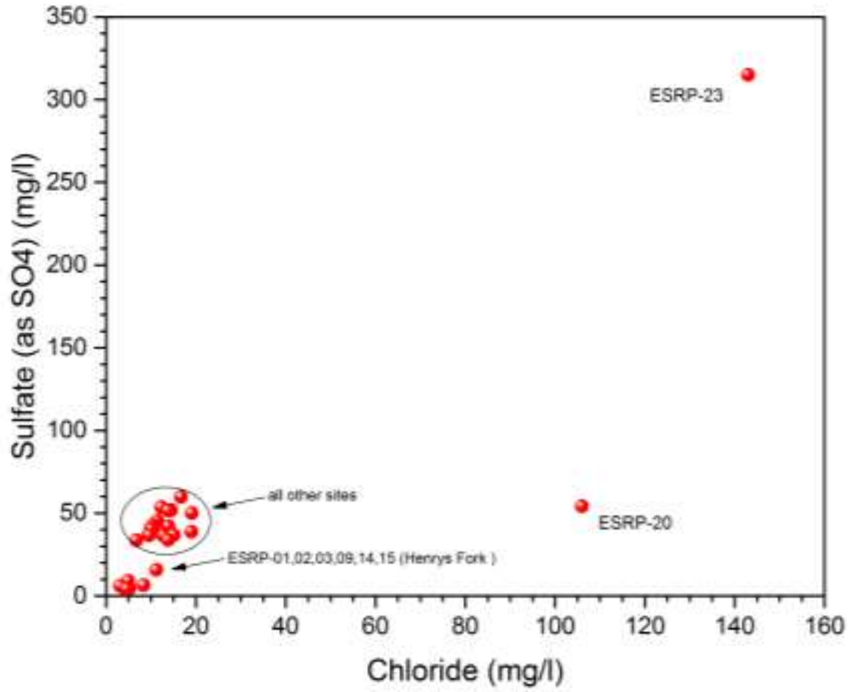


Figure 15. Comparison of chloride versus sulfate concentrations—Eastern Snake River Plain Regional Ground Water Monitoring Project.

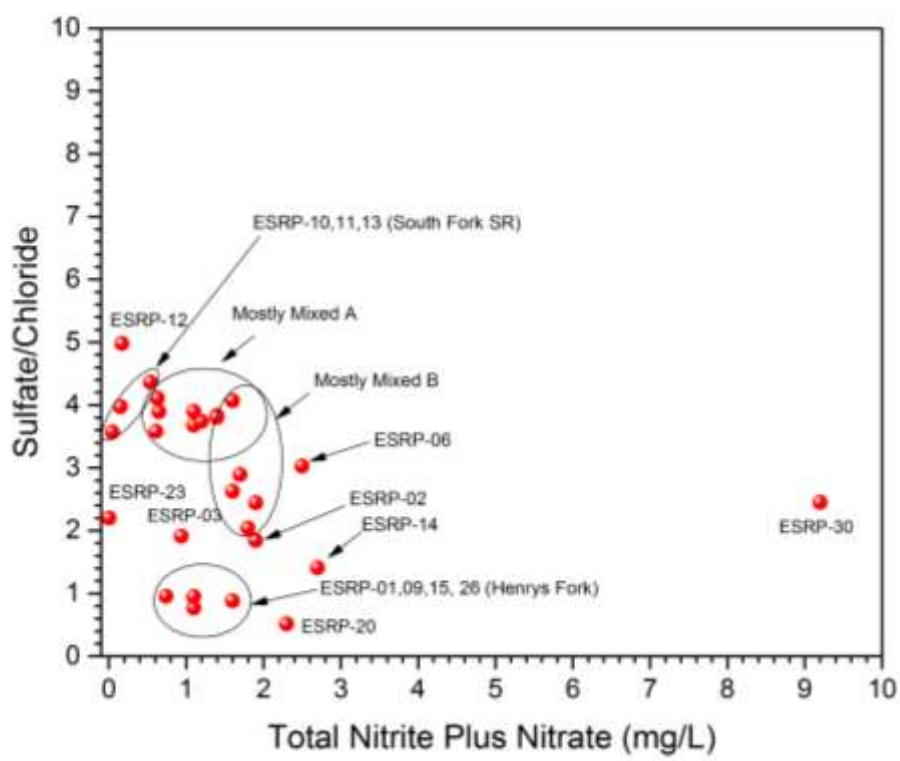


Figure 16. Nitrite plus nitrate versus sulfate/chloride—Eastern Snake River Plain Regional Ground Water Monitoring Project.

Nitrate Results and Ground Water Flow

Nitrate concentrations ranged from 0.004 mg/L to 9.2 mg/L, with a mean and median of 1.50 and 1.15 mg/L, respectively. The highest value was from outside the ESRP subarea near Hamer, within the Mudlake NPA. The highest nitrate values within the study area are 2.7, 2.5, and 2.3 mg/L (sites ESRP-14, 06, and 20). The mean result for samples within the study area was 1.21 mg/L.

Stable Isotopes

Figure 17 and Figure 18 present stable isotope measurements of $\delta^{15}N_{nitrate}$ compared to nitrite plus nitrate and compared to sulfate/chloride ratios. Most steps in the nitrogen cycle in the subsurface are facilitated by microbes and can result in isotope fractionation (changes in the observed stable isotope ratio). Heaton (1986) observed a range of $\delta^{15}N$ ratios for water samples influenced by difference sources of nitrogen to the environment. Seiler (1996) summarized those ranges (Table 4) and applied his findings to differentiating potential nitrate sources based on $\delta^{15}N$ isotopic ratios. For analysis of $\delta^{15}N$, the observed isotopic ratio is compared to a known standard; in this case, the standard is $\delta^{15}N$ for air. The analysis method utilized by CPSIL for stable $\delta^{15}N$ measurements is sensitive only for nitrogen in the form of nitrate ($\delta^{15}N_{nitrate}$). Oxygenated ground water favors nitrogen in the form of nitrate. Samples for 7 sites with low dissolved oxygen and detectable ammonia were analyzed by the University of Arizona for total $\delta^{15}N$ (Table 17).

Results for $\delta^{15}N_{nitrate}$ ranged from 1.11 to 7.02 ‰, with 13 within the range (<4‰) indicative of inorganic nitrogen/commercial fertilizer. The well with the greatest nitrite plus nitrate result (ESRP-30), returned a value of 1.1‰ (Figure 17). The sample from ESRP-23, with a nitrite plus nitrate result of 0.004 mg/L, did not have sufficient nitrate for the analysis method used CPSIL. The $\delta^{15}N$ result for this site was 5.1‰ as measured by the University of Arizona. ESRP-01, 08, 26, and 30 and many of the South Fork and mixed groupings A and B from the Piper diagram (Figure 14) plot in the range indicative of an inorganic nitrate source. Natural precipitation is expected to have a $\delta^{15}N$ value near 0‰. ESRP-01 and 26 both have low sulfate/chloride, low nitrate, and a low $\delta^{15}N$ value. It's possible that the signature from these sites represents a predominantly natural, atmospheric source. Other sites, including ESRP-03, 23, 12, and 16, likely represent a mixture of sources. The very low nitrate value, anoxic well conditions (dissolved oxygen 0.08 mg/L), and $\delta^{15}N$ value of 5.1 for ESRP-23 may suggest that denitrification could be occurring for this site, though more information is needed to confirm that. Generally, the range of sulfate/chloride vs $\delta^{15}N_{nitrate}$ values suggests inorganic or mixed nitrogen sources as opposed to waste-related sources for sites sampled.

Stable isotopes of oxygen and hydrogen in ground water can help identify the likely source and timing of recharge. Results for $\delta^{18}O$ and $\delta^{2}H$ (deuterium) for water are reported relative to Vienna Standard Mean Ocean Water (VSMOW). Results for $\delta^{18}O$ versus $\delta^{2}H$ for ESRP subarea ground water are presented in Figure 19, along with results for the Teton-Basin-Ashton regional monitoring from 2013. The figure also includes for comparison the global meteoric water line (GMWL) from Craig (1961), a local meteoric water line (LMWL) based on regional precipitation, and a compilation of ground water $\delta^{18}O$versus $\delta^{2}H$ from Cecil et al. (2005). From the Teton Basin-Ashton regional monitoring summary last year, the primary source or recharge was determined to be dominated by local snowmelt that reflected the global and local meteoric water lines. ESRP results for $\delta^{18}O$ versus $\delta^{2}H$ for all but one site (ESRP-23) plot very closely along that LMWL. Such a close grouping along the LMWL for most sites supports the observation of recharge sources from the Piper diagram (Figure 14); recharge reflects gains from the Henrys Fork and South Fork of the Snake River, as opposed to recharge from evaporated irrigation water. The exception to this is ESRP-23, likely dominated by local irrigation.

Kendall (1998) discusses the use of $\delta^{15}N_{nitrate}$ and $\delta^{18}O_{nitrate}$ to aid in tracing sources and nitrogen cycling in the environment. This dual-isotope method can help explain the ongoing microbial-facilitated processes and aid in understanding portions of the nitrogen cycle where $\delta^{15}N$ signatures are not sufficiently distinct. Figure 20 plots $\delta^{15}N_{nitrate}$ versus $\delta^{18}O_{nitrate}$ for ESRP subarea samples. Also included are typical ranges for $\delta^{15}N_{nitrate}$ versus $\delta^{18}O_{nitrate}$ for various sources (Kendall et al. 2007). Results for $\delta^{15}N_{nitrate}$ are reported relative to $\delta^{15}N$ in air and $\delta^{18}O_{nitrate}$ is reported relative to VSMOW. As nitrogen in the form of ammonia undergoes nitrification, oxygen from the air and from soil or irrigation water is added; the typical ratio is one $\delta^{18}O$ from air (usually $\delta^{18}O$ = 23‰) and two from the soil water, either precipitation or irrigation water ($\delta^{18}O$ ~ -17‰), from Table 17 and Figure 19, yielding an expected $\delta^{18}O$ value of ~ -4 or -5‰ (Kendall 1998).

Results for all sites plot in a range that reflects sources including inorganic nitrogen, likely from ammonium-based fertilizer that has undergone nitrification with water from local precipitation or irrigation water (as interpreted from Table 17 and Figure 19), or a combination of inorganic nitrogen and soil nitrogen. No sites plot in regions clearly indicative of nitrates from nitrate-based fertilizer, nitrates from atmospheric sources (direct from precipitation), or from denitrification.

Current research favors analyzing for $\delta^{15}N_{nitrate}$ as this analysis provides more information concerning how nitrogen is cycling in the environment. DEQ has historically analyzed for both total $\delta^{15}N$ and $\delta^{15}N_{nitrate}$. Inherently different methods are used to prepare the samples used to measure the $\delta^{15}N$ isotopic ratio; thus, the results are not numerically equal. To understand differences between results from these methods, samples from 6 selected sites (ESRP-02, 03, 04, 10, 16, and 17) were analyzed for both $\delta^{15}N$ and $\delta^{15}N_{nitrate}$ (Table 17). Samples from 4 of the 6 sites reported detectable ammonia. The denitrifying-bacteria method for $\delta^{15}N_{nitrate}$ and $\delta^{18}O_{nitrate}$ analysis does not capture the signature of $\delta^{15}N$ for N in the form of ammonia. Figure 21 shows a comparison of $\delta^{15}N_{nitrate}$ and total $\delta^{15}N$ for these samples. Upon initial review, the $\delta^{15}N_{nitrate}$ method resulted in a lighter isotopic ratio compared to the $\delta^{15}N$ method, with the difference between the values being greater where the ammonia and nitrite plus nitrate results were closer in magnitude. In most cases, the $\delta^{15}N_{nitrate}$ and total $\delta^{15}N$ results were within approximately 1 permil (‰). A preliminary conclusion is that results for $\delta^{15}N$ by both methods are comparable when both ammonia and nitrite plus nitrate are known. A more detailed review and summary of this data will be presented in the technical report.

A potential explanation is the inherent difference between the analysis methods. For the $\delta^{15}N_{nitrate}$ analysis, a biological process is used to prepare the sample; for the total $\delta^{15}N$ analysis, a chemical process is used. As the difference between the methods for most of the samples appears to be within expected tolerances—and additional differences can be explained by accounting for the form of the nitrogen in the sample—more recent $\delta^{15}N_{nitrate}$ analysis results can be compared with historical total $\delta^{15}N$ results, with an understanding of relative errors and the higher bias of the total $\delta^{15}N$ analysis. Analysis that will capture the $\delta^{15}N$ is needed for samples with detectable ammonia. The Colorado Plateau Stable Isotope Laboratory does have a bacterially based method for $\delta^{15}N$ of ammonia.

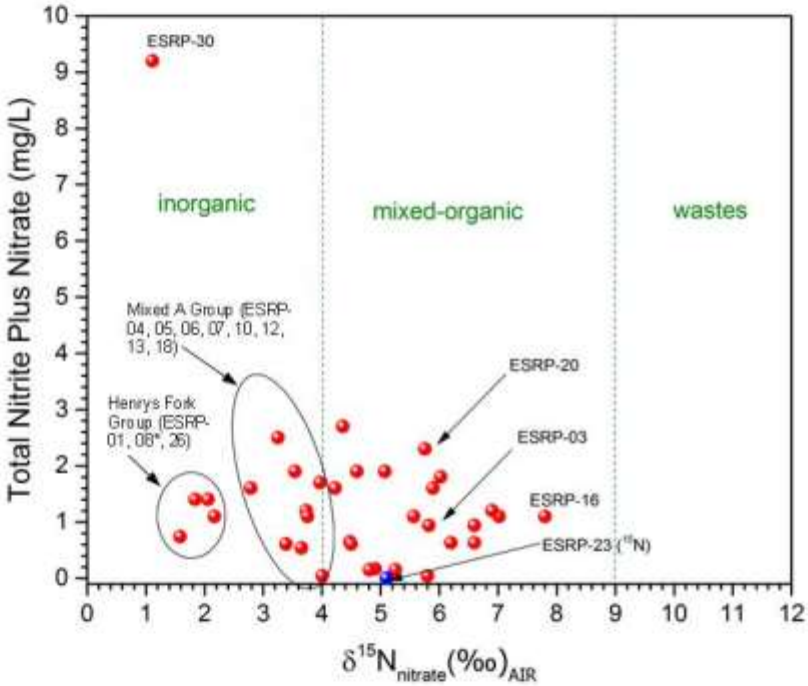


Figure 17. Nitrite plus nitrate versus $\delta^{15}N_{nitrate}$ —Eastern Snake River Plain regional monitoring subarea. Ranges for typical nitrate sources are from Kendall et al. 2007. * Henrys Fork grouping includes the duplicate for well ESRP-08.

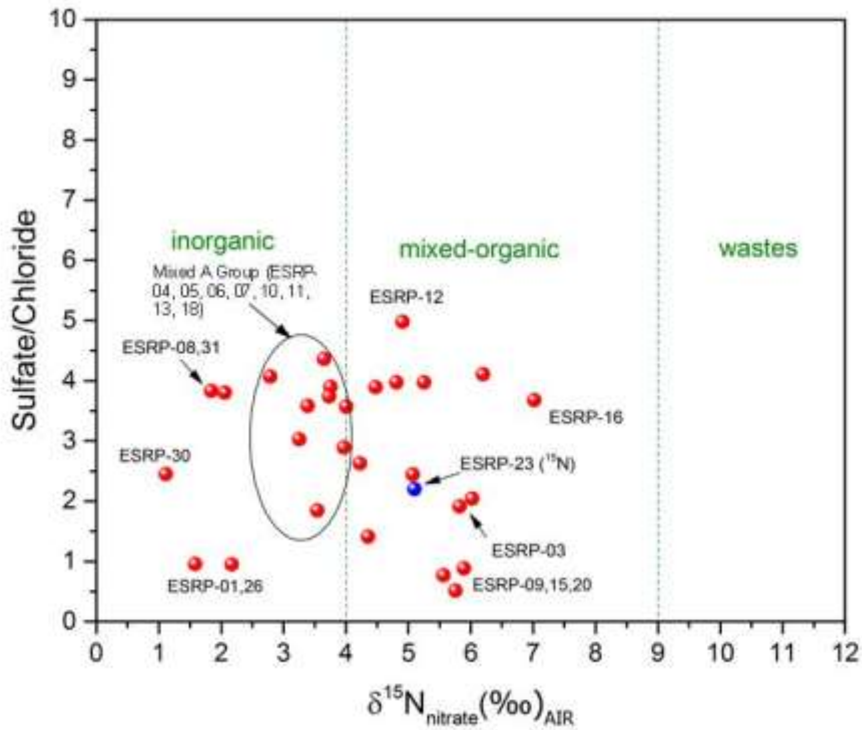


Figure 18. Sulfate/chloride nitrate versus $\delta^{15}N_{nitrate}$—Eastern Snake River Plain regional monitoring subarea. Ranges for typical nitrate sources are from Kendall et al. 2007.

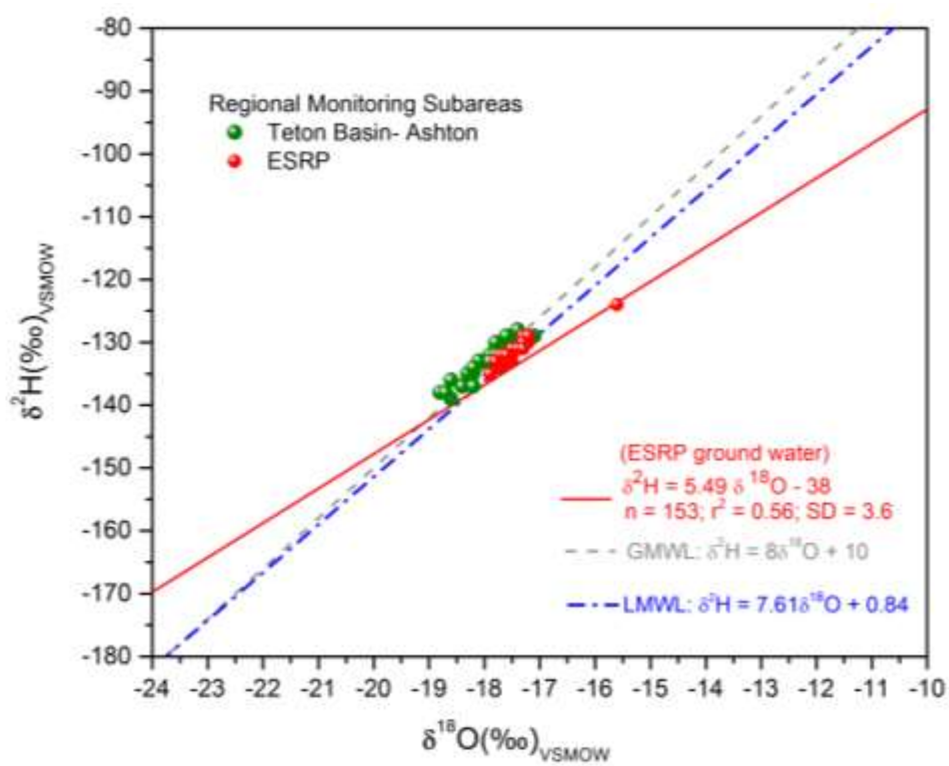


Figure 19 Stable oxygen and deuterium ($\delta^{18}O$ versus $\delta^{2}H$) —Eastern Snake River Plain regional monitoring project.

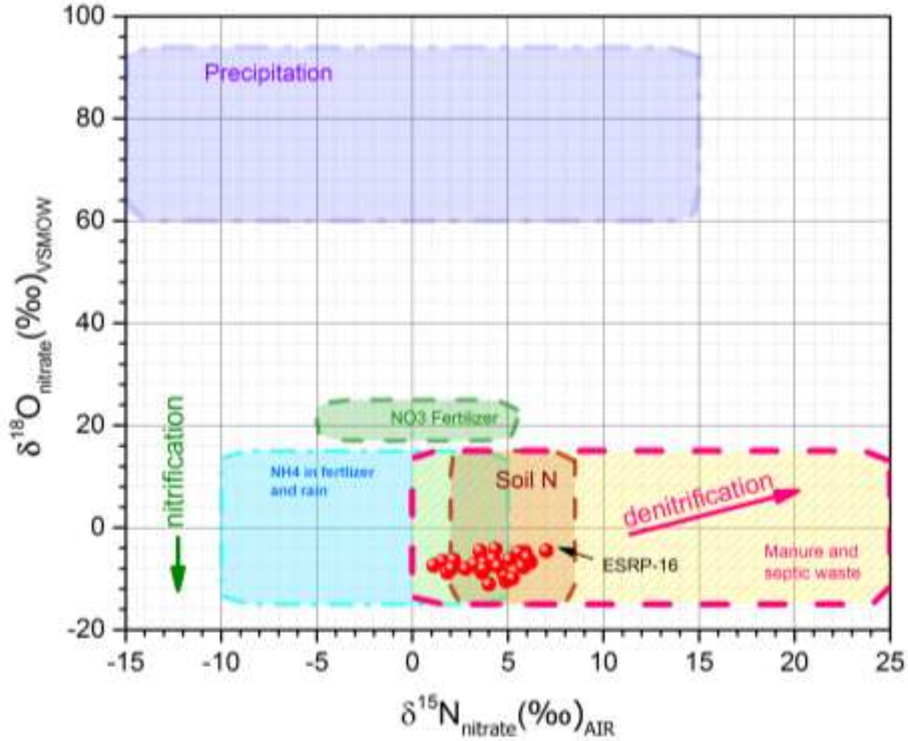


Figure 20. $\delta^{15}N_{nitrate}$ versus $\delta^{18}O_{nitrate}$ —Eastern Snake River Plain Regional Ground Water Monitoring Project. Ranges for typical nitrate sources are from Kendall et al. 2007.

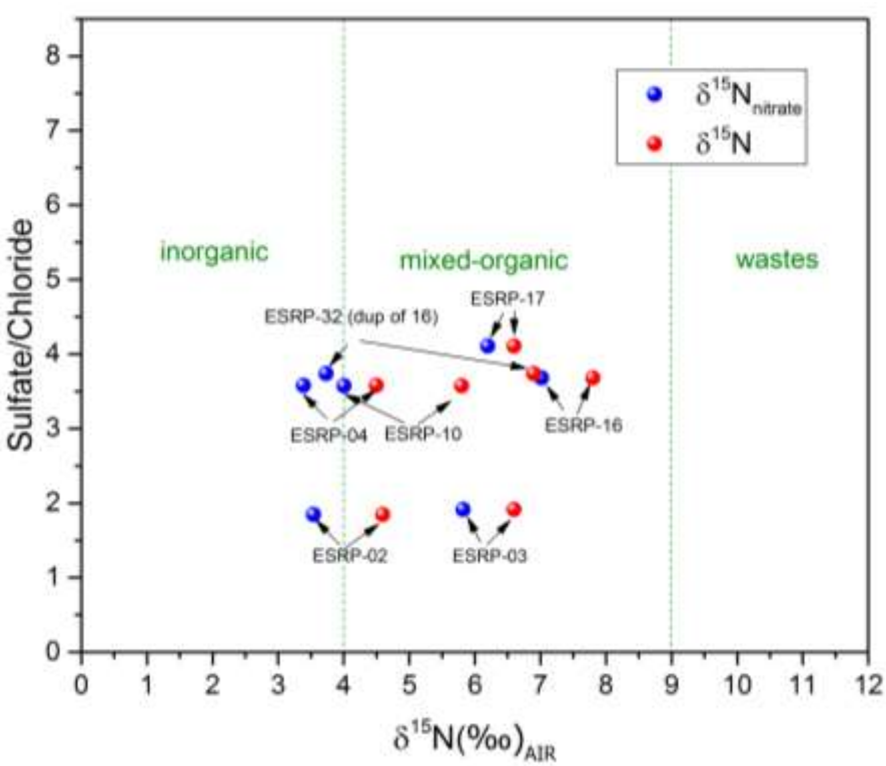


Figure 21. Comparison of $\delta^{15}N_{nitrate}$ and total $\delta^{15}N$ vs sulfate/chloride for sites where both N isotope analyses were conducted—Eastern Snake River Plain regional monitoring project.

Characteristic Ratios and Trace Elements

Relative concentrations of trace constituents in ground water can provide additional support to distinguish between potential sources of nitrates. Ratios of chloride to bromide and relative concentration of boron have been used as indicators by Katz et al. (2011) and Davis et al. (1998). Chloride and bromide both travel conservatively in ground water and have varying abundances in natural materials. Bromide has a slightly greater aqueous solubility compared to chloride, allowing Cl/Br ratios to be useful in distinguishing recharge sources. Bromide can be selectively added as organic matter decays, and Cl/Br ratios can aid in distinguishing between recharge sources and identifying impacts from wastewater (Davis et al. 1998; Pastén-Zapata et al. 2014). Characteristic Cl/Br ratios range from 50 to 150 for precipitation, 100–200 for shallow ground water, 300–600 for septic-influenced ground water, and >1,000 for ground waters affected by dissolution of evaporates (Davis et al. 1998; Katz et al. 2011). Boron, as a trace constituent in many cleaning products, can support an indication of a waste-related influence as suggested by other tracers.

Bromide was reported at detectable levels for 5 of the 27 sample sites: ESRP-06, 14, 19, 20, and 23 (Table 18). IBL has a standard minimum reporting level of 0.80 mg/L with the EPA 300.0 method. However, IBL was able to achieve a minimum detection level of 0.034 mg/L for samples with positive detections. Bromide concentrations ranged from 0.14 to 0.98 mg/L. Chloride/bromide ratios versus chloride are presented in Figure 22**.** Ratios from two sites (ESRP-20 and 23) were in the range potentially correlated to septic wastes. The remaining sites (ESRP-06, 14, and 19) reflected a range more characteristic of precipitation. Boron analysis was conducted on 4 of the 5 samples with positive bromide detections (ESRP-06, 14, 19, 20). Boron results for all 4 samples had positive detections and ranged from 0.069 to 0.16 mg/L. A positive detection of boron is potentially indicative of a ground water quality impact from waste sources.

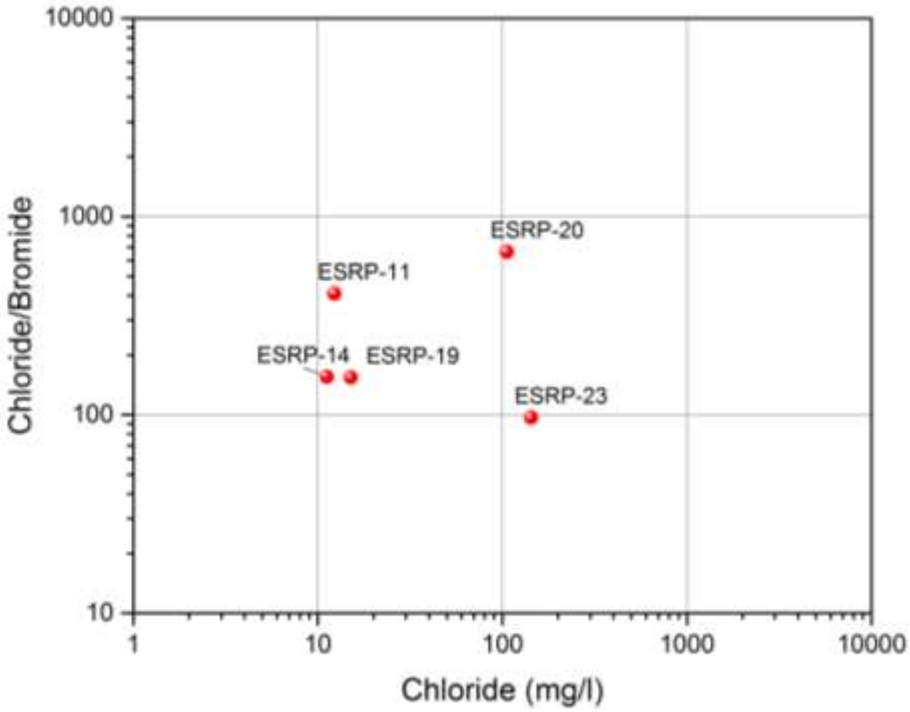


Figure 22. Chloride/Bromide versus chloride for those sites with detectable bromide—Eastern Snake River Plain Regional Ground Water Monitoring Project.

The occurrence of arsenic in domestic wells in the Roberts–Market Lake basin was the subject of a DEQ technical report (DEQ 2008). The investigators drew a correlation between anoxic/very low dissolved oxygen conditions and the presence of arsenic in ground water. ESRP-23 is located near the Roberts area and was analyzed for arsenic based on the anoxic conditions (<1.0 mg/L dissolved oxygen) indicated from field measurements and presence of arsenic in nearby wells. IBL has a standard minimum reporting level of 0.005 mg/L with the EPA 200.8 method. However, IBL was able to quantify arsenic at 0.0038 mg/L (3.8 µg/L) for the sample from the listed site (Table 18). The MCL for arsenic is 10.0 µg/L.

Well Completion and Nitrate Levels

A well-selection criterion for regional ground water monitoring projects requires that a well log be available, or that well construction can otherwise be established. These criteria favor selecting wells with a more recent construction date. These more recently constructed wells tend to have more complete information concerning well construction, well-bore seals, and lithologic descriptions. Wells constructed to more current standards are more likely to yield water quality information representative of the regional ground water and anthropogenic impacts from the land surface, instead of conditions specific to that individual well. No correlation was apparent between depth of casing and nitrite plus nitrate for ESRP subarea wells. Well owner activities and maintenance at the well are also factors that may have an influence on vulnerability to contamination at the wellhead.

2.2.1.3 Conclusions

The objectives of this regional monitoring study are to identify areas of vulnerable or degraded water quality, collect data to aid in determining potential sources of degradation to direct and prioritize protection efforts based on potential sources, and to evaluate the effectiveness of protection measures to reduce nitrate impacts. This summary presents preliminary results for the second of three regional monitoring subareas for the Idaho Falls DEQ region.

- Nitrite plus nitrate concentrations exceeded 2 mg/L for 4 of 27 wells; 1 well—ESRP-30, which is located near Mud Lake and outside of the ESRP subarea project area—had a concentration of 9.2 mg/L, which approaches the drinking water MCL of 10 mg/L. Ammonia was detected at 5 sites, ranging from 0.014 to 0.27 mg/L.
- Major ion chemistry, presented with a Piper trilinear diagram, suggested that the variation in major ions can be explained as primarily a mixture of recharge from the Henrys Fork and South Fork of the Snake River. The Piper diagram suggests a general increase in the relative proportion of sulfate in ground water from north to south. Two wells (ESRP-20 and ESRP-23) are distinct from the other locations by significantly greater proportions of sulfate and chloride.
- The relationship of sulfate/chloride provides a basis for distinguishing between some wells; wells with higher relative sulfate tended to also plot with a lower $\delta^{15}N_{nitrate}$ value, in the range typical for inorganic nitrate. The well with the lowest sulfate/chloride ratio showed other characteristics supporting a waste-related influence. Some wells with a lower relative sulfate also reflected a grouping related to Henrys Fork recharge and lower sulfate/chloride ratio, suggesting that in some cases the low relative sulfate may reflect natural water chemistry.
- Trace/minor ground water constituents bromide and boron appeared successful as screening tools to distinguish between nitrate sources, specifically helping to distinguish septic or sewage sources.
- Stable isotopes of nitrogen ($\delta^{15}N_{nitrate}$, total $\delta^{15}N$), supported by chemistry and other indicators, suggest that the ESRP subarea is primarily impacted by inorganic nitrogen sources—primarily fertilizer—and potentially some nitrogen from precipitation. Mixed inorganic and organic sources are suggested for some sites. None of the wells showed a strong waste signature based on nitrogen isotopes.
- Differing measures of nitrogen isotopes ($\delta^{15}N_{nitrate}$, total $\delta^{15}N$) are comparable. Results for $\delta^{15}N_{nitrate}$ and total $\delta^{15}N$ for sites with low dissolved oxygen and detectable ammonia as N were compared. Total $\delta^{15}N$ was higher than $\delta^{15}N_{nitrate}$ for all sample pairs, with differences greater where ammonia and nitrite plus nitrate concentrations were closest.
- $\delta^{18}O$ and $\delta^{2}H$ values plot along the LMWL suggesting that recharge is a general average of precipitation for the region. One well (ESRP-23) plots along the regional ground water/evaporation line, suggesting that recharge for that site in likely influenced by evaporation of irrigation water.
- No relationship was observed between nitrate concentrations and depth of casing for wells, suggesting that other factors in addition to simply depth of casing are needed to predict well vulnerability.

2.2.1.4 Recommendations

- Major ion chemistry, chloride, sulfate, and stable isotopes should be considered for sampling to identify potential nitrate sources. Addition of bromide and boron did provide new information. Laboratory reporting levels sufficiently sensitive for these analytes should be requested.
- The dual isotope method—$\delta^{15}N_{nitrate}$, $\delta^{18}O_{nitrate}$—provides more diagnostic information with regard to possible nitrogen sources than $\delta^{15}N$ alone. While $\delta^{15}N_{nitrate}$ and total $\delta^{15}N$ results are comparable, future sampling should include a bacteria-based method from CPSIL for $\delta^{15}N$ on samples with ammonia.
- Regional $\delta^{18}O$ and $\delta^{2}H$ for ground water should be characterized, as the isotopic nature of ground water can provide insight to timing of recharge and potential ongoing processes in the nitrate cycle.
- Age of well, depth of seal, and drilling methods could be considered for evaluating the impact of well conditions/construction on vulnerability.

2.3 Coeur d'Alene Region

No ground water quality projects were conducted using DEQ funds in the Coeur d'Alene region in 2014.

2.4 Lewiston Region

Three ground water quality monitoring projects were conducted in the Lewiston region in 2014 using public funds.

2.4.1 Camas Prairie Ground Water Monitoring Project

This section summarizes the 2014 sampling results from an ongoing ground water quality evaluation of nitrate concentrations in the Camas Prairie, north of Grangeville, Idaho. A DEQ investigation by Bentz (1998) found that 24 of 55 wells sampled (44%) had nitrate concentrations that exceeded 5 mg/L, which is half the MCL of 10 mg/L. The maximum nitrate concentration reported in the 1998 study was 77.1 mg/L. That value was later determined to be from a point source near the wellhead and the site has not been sampled in subsequent years. The Camas Prairie is in one of Idaho's NPAs (the Clearwater Plateau NPA), designated in part on the 1998 nitrate investigation results. In 2014, the Clearwater Plateau NPA ranked as the 14th most degraded area in the state; data used in the assessment indicated a decreasing trend in nitrate concentrations.

2.4.1.1 Purpose and Background

To address elevated nitrate concentrations in the Camas Prairie, a ground water quality management plan (GWQM plan) was developed (DEQ and ISCC 2008). The GWQM plan encourages implementation of voluntary best management practices (BMPs) to reduce nitrate concentrations in ground water.

As part of the plan, approximately $1 million of Clean Water Act §319 grant funds were expended on the Camas Prairie through 2011 for implementing agricultural ground water protection BMPs, such as direct seed practices. Direct seed practices allow for crop planting with minimal soil disturbance, which may contribute to reduced nitrogen mobility when combined with other BMPs.

DEQ initiated the Camas Prairie ground water monitoring program in August 2005 as part of a regional ambient ground water monitoring network. The objective of this long-term ground water monitoring is to determine the GWQM plan’s effectiveness in improving ground water quality. Nitrate concentration data will be periodically evaluated to determine if ambient concentrations increase or decrease. This evaluation will include seasonal and overall trend assessment.

The project area is located immediately north of Grangeville, Idaho, straddling Lewis and Idaho Counties and encompassing the towns of Cottonwood, Ferdinand, Craigmont, and Nezperce (Figure 23). The land use is primarily agricultural, specifically dry-land farming. Rangeland and grazing are also commonly found throughout the area.

The geology of the area is characterized by the Tertiary Columbia River Basalts and consists of units that formed when lava flows filled in the pre-existing basement rock topography during the Miocene era (Stevens et al. 2003). The majority of the area is capped with a thin layer of loess. Ground water in the area is most commonly found in the basalt aquifers and occasionally in the alluvial valley aquifers and basement rocks. Ground water generally flows to the north and eventually discharges into the Clearwater River (Hagan 2003). Well depths from ground water sampling ranged from 28 to 500 feet.

2.4.1.2 Methods and Results

Since 2006, DEQ has conducted routine quarterly sampling from the Camas Prairie network of 23 wells and up to 2 springs for a total of 25 sampling sites. Nitrate concentrations from sampled sites were compared seasonally for several years to identify wells with similar seasonal trends and wells with apparent anomalies. Wells with reported results that were considered to be anomalies were addressed to identify and resolve isolated or localized situations and dropped from the ambient monitoring network.

In 2014, ambient sampling was conducted in March, September, and December in accordance with the Camas Prairie ground water sampling QAPP (DEQ 2005). June sampling did not take place due to staffing shortages. Samples were collected from as many as 24 wells and 1 spring during the three rounds of sampling (Table 19; Figure 23). Six wells were not consistently sampled in all three sampling rounds due to lack of water/low water or access issues.

Figure 23 shows well locations and nitrate results for the September sampling event. Water quality field parameters of water temperature, specific conductance, and DO were measured prior to sample collection for nitrates (Table 19).

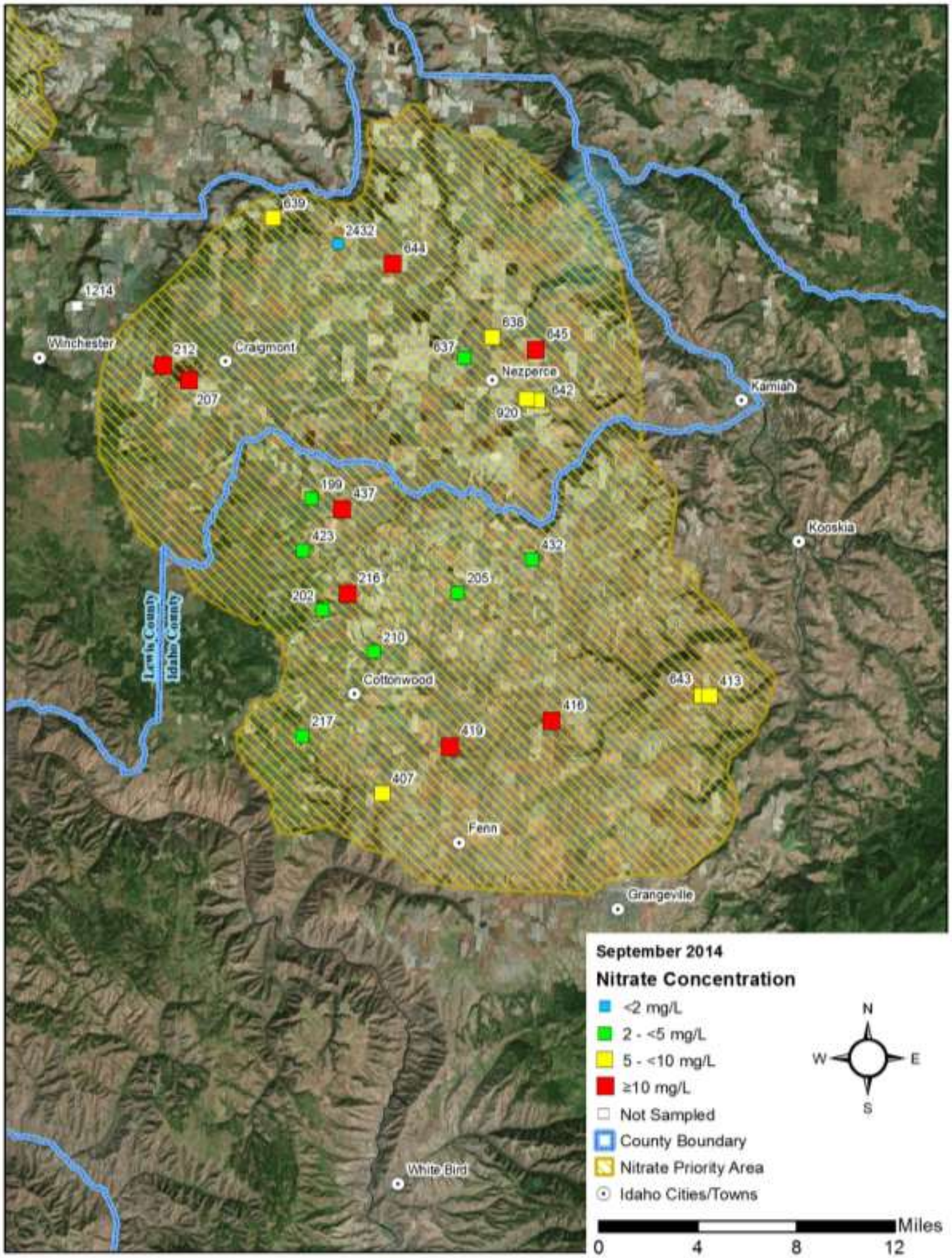


Figure 23. Well and spring locations, DEQ site IDs, and September nitrate concentrations—Camas Prairie Ground Water Monitoring Project, September 2014.

Table 19. Water quality field parameters—Camas Prairie Ground Water Monitoring Project.

		March 2014			September 2014			December 2014		
Site ID	**Well Depth (feet)**	**Spec. Cond. (µs/cm)**	**Water Temp. (°C)**	**DO (mg/L)**	**Spec. Cond. (µs/cm)**	**Water Temp. (°C)**	**DO (mg/L)**	**Spec. Cond. (µs/cm)**	**Water Temp. (°C)**	**DO (mg/L)**
199	140	525	9.8	9.31	475	12.5	—	NS	NS	NS
202	400	228	9.7	7.43	291	12.2	—	251	9.3	—
205	327	550	10.4	0.55	552	11.8	—	522	9.8	—
207	85	731	9.4	3.76	394	10.2	—	474	8.3	—
210	500	349	13.5	6.31	336	15.7	—	337	12.6	—
212	400	NS	NS	NS	414	13.7	—	423	11.2	—
216	80	583	10.9	7.17	592	15.2	—	588	12.9	—
217	500	268	5.5	5.88	267	15.0	—	269	7.8	—
407	375	345	5.9	8.86	397	15.8	—	376	7.2	—
413	260	430	5.6	13.26	408	16.7	—	439	10.1	—
416	187	NS	NS	NS	453	13.2	—	452	8.0	—
419	250	727	8.3	5.06	646	11.1	—	668	8.3	—
423	500	229	7.2	7.61	239	10.9	—	231	8.3	—
432	135	359	10.8	3.17	361	11.5	—	364	10.5	—
437	28	645	6.0	8.88	526	11.5	—	NS	NS	NS
637	396	403	8.6	12.49	403	11.8	—	405	9.0	—
638	90	410	8.1	10.25	438	11.0	—	432	10.4	—
639	85	613	8.6	7.35	613	12.3	—	621	6.8	—
642	65	635	10.8	8.56	475	11.5	—	495	9.7	—
643	145	345	6.0	8.63	436	16.6	—	385	6.7	—
644	402	514	9.4	10.99	510	11.7	—	520	9.2	—
645	165	655	10.0	8.45	675	11.9	—	631	10.2	—
920	300	439	6.1	9.23	450	14.2	—	451	7.7	—
1214	Spring	327	5.6	5.18	NS	NS	NS	NS	NS	NS
2432	400	NS	NS	NS	273	15.1	—	NS	NS	NS

Notes: (—) = data are unavailable or were not analyzed .NS = not sampled.

The highest reported nitrate concentration was 21.9 mg/L collected from site 437 during the March sampling event. Site 419 had the highest reported mean nitrate concentration from all three sampling events, with an annual mean of 20.13 mg/L. Overall, 9 of the 24 sampled sites reported nitrate concentrations in excess of the EPA MCL of 10 mg/L at least once during the 2014 sampling year (Table 20). Quarterly means from all wells in the monitoring project ranged from 7.90 mg/L to 8.54 mg/L. Project-wide, nitrate concentrations were highest in March and lowest in September.

Table 20. Nitrate results—Camas Prairie Ground Water Monitoring Project.

Site ID	Well Depth (Feet)	Nitrate Concentration in milligrams per liter (mg/L)			
		March 2014	September 2014	December 2014	Yearly Mean[a]
199	140	9.23	4.66	NS	6.95
202	400	3.34	4.26	3.78	3.79
205	327	4.28	4.17	3.59	4.01
207	85	**16.5**	**12.5**	**14.4**	**14.47**
210	500	3.96	3.40	3.84	3.73
212	400	**17.8**	**17.4**	**18.3**	**17.83**
216	80	**10.3**	**10.0**	**11.8**	**10.70**
217	500	3.01	2.25	2.63	2.63
407	375	4.1	8.74	6.51	6.45
413	260	6.48	5.67	6.06	6.07
416	187	NS	**17.2**	**17.4**	**17.30**
419	250	**20.5**	**19.1**	**20.8**	**20.13**
423	500	2.15	2.95	2.14	2.41
432	135	4.45	4.00	4.09	4.18
437	28	**21.9**	**10.4**	NS	**16.15**
637	396	4.82	4.9	4.62	4.78
638	90	4.82	5.39	5.22	5.14
639	85	5.58	5.32	5.43	5.44
642	65	**11.4**	6.36	6.87	8.21
643	145	5.7	8.1	6.62	6.81
644	402	**11.3**	**11.2**	**11.5**	**11.33**
645	165	**14.8**	**15.5**	**14.0**	**14.77**
920	300	5.85	5.88	6.0	5.91
1214	Spring	4.15	NS	NS	—
2432	400	NS	0.217	NS	—
Mean		**8.54**	**7.90**	**8.36**	**8.26**

Notes: Bolded red numbers indicate the US Environmental Protection Agency's maximum contaminant level of 10 mg/L was reached or exceeded; NS = not sampled; (—) indicates data are not available or were not analyzed.
[a] Yearly means were not calculated for sites that were sampled for less than 2 sampling events.

A histogram of all nitrate samples in the project area for 2014 is shown in Figure 24. A Kruskal-Wallis analysis was performed to test for seasonal differences between the synoptic sampling events across the monitoring area. No evidence suggests significant differences ($p = 0.97$) between the three sampling events in 2014.

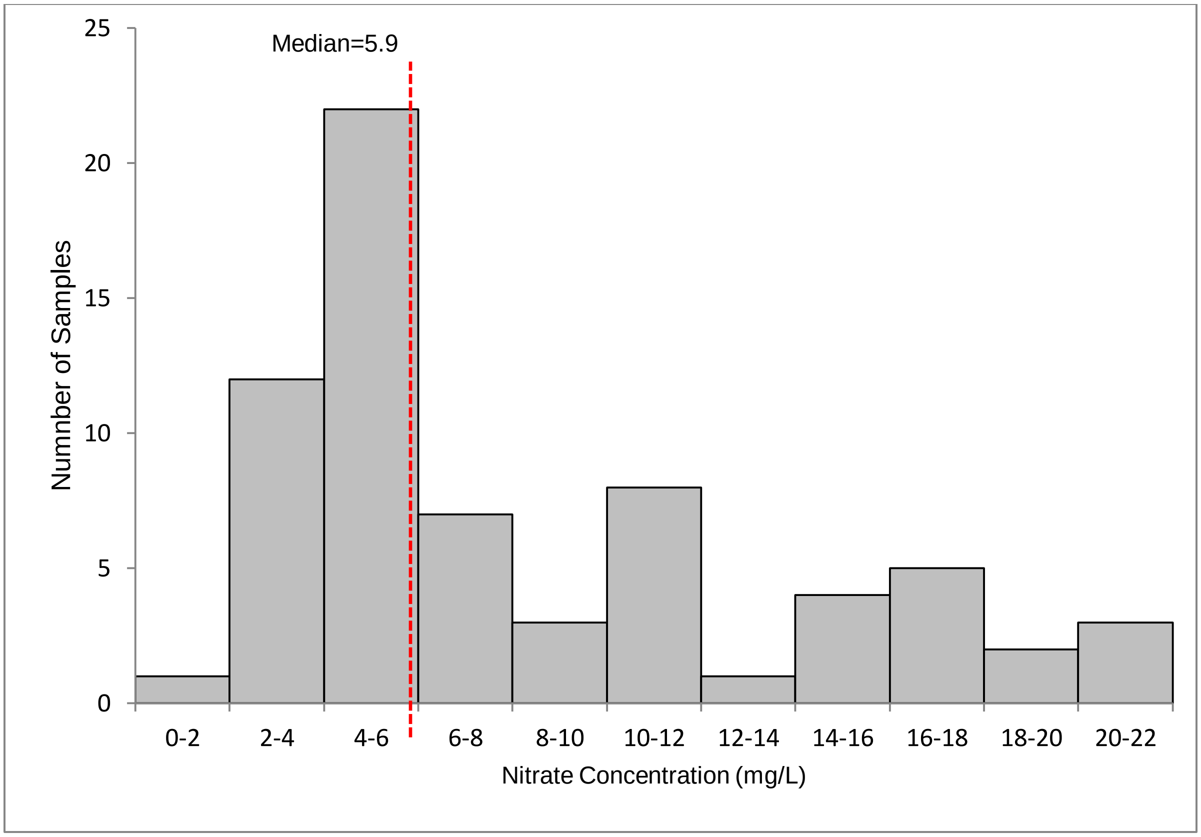


Figure 24. Histogram of nitrate concentrations of all nitrate samples (n = 68)—Camas Prairie project area. The median nitrate concentration value is below the MCL of 10 mg/L.

Seasonal fluctuations and trends in nitrate concentrations in Camas Prairie wells were also evaluated visually using scatterplots (Figure 25). No seasonality patterns could be determined from the plots.

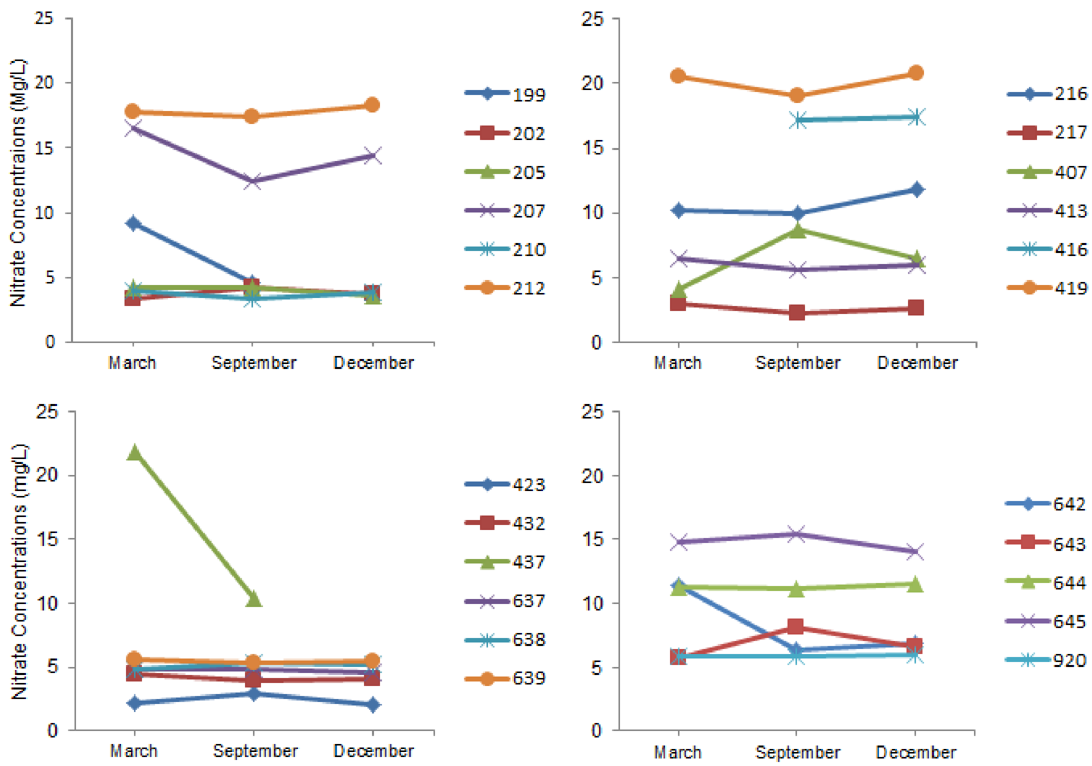


Figure 25. Scatterplots of nitrate concentrations of all nitrate samples with at least two samples—Camas Prairie project area.

2.4.1.3 Conclusions

The objective of this long-term ground water monitoring is to determine the effectiveness of the GWQM plan in improving ground water quality. Sampling of wells and springs in the project area during 2014 will help realize this objective. Sample results show that ground water in the Camas Prairie contains elevated nitrate concentrations, with some locations exceeding the EPA MCL of 10 mg/L; however, during the 2014 NPA review process, the Clearwater Plateau NPA showed a decreasing trend. A decreasing trend in nitrate concentrations could suggest that the GWQM plan is helping to reduce nitrate concentrations in ground water.

Nitrogen isotope analysis from previous years indicates that both inorganic and organic nitrogen contribute to the elevated concentrations (DEQ 2013e). Based on the large areal extent of degraded ground water, commercial fertilizer, livestock manure, and septic discharge are all potential sources of elevated nitrate concentrations detected within the project area.

2.4.1.4 Recommendations

Annual variability reported for individual wells makes it difficult to detect improvements in ground water quality in the project area as BMPs are implemented because concentration changes may be within the range of historic concentrations reported for individual wells. Therefore, this project will attempt to compare changes in seasonal trends of the network over multiple years to identify changes in ambient conditions.

Tracking changes in ambient nitrate concentrations relative to changes in land use or source controls could be accomplished by comparing changes in seasonal trends over multiple years to minimize the effects of seasonal variability that occur under the conditions mentioned above. As of now, nitrate data have been collected for 9 years. Completion of an initial analysis of effectiveness of BMPs through evaluation of nitrate levels over time, reported through a technical report, is recommended for fiscal year 2015.

Due to the repeated lack of significant difference between average nitrate concentrations of quarterly sample events for several years, changing sample events to annual rather than quarterly may provide sufficient temporal nitrate data. Multiyear seasonality would therefore be taken out of the management plan for this area. Upon completion of a technical report for nitrate data from 2005–2014, which will determine if seasonality is significant, it may be recommended that sampling continues on an annual basis. Additionally, the continued collection of data helps support the NPA trend analysis process.

Ground water conditions can be represented in spring water. Monitoring spring water when ground water provides the only source of water to a spring can also be used to determine ground water nitrogen loads to surface water. This information may be useful in determining if and where ground water nitrogen is contributing to surface water concentrations within the drainage basin. The information may also be useful in identifying areas to focus BMP implementation efforts. A report by Baldwin et al. (2008), which summarizes data collected for this project from 2005 through 2007, is a resource for additional information.

2.4.2 Tammany and Lindsay Creeks Ground Water Monitoring Project

2.4.2.1 Purpose and Background

The Lindsay Creek NPA was designated in 2008 using ground water quality data from the IDWR, ISDA, USGS, and DEQ. The NPA encompasses the Lindsay and Tammany Creek watersheds. The 2007 Lindsay Creek total maximum daily load (TMDL) determined that ground water base flow is a nitrogen contributor to Lindsay Creek and requires a reduction in nitrogen loading (DEQ 2007).

The goal of this project is to create an ambient ground water quality monitoring network to complete a multiple year seasonal trend analysis to detect changes that are a result of the Lindsay Creek NPA designation and also extend ground water quality monitoring to include the aquifer within the Tammany Creek watershed.

The project area is located east and southeast of Lewiston, Idaho. The land use is primarily agricultural, specifically dry-land farming. Rangeland and grazing are also common in the area. The area is underlain by the Tertiary Columbia River Basalts and consists of units that formed when lava flows filled in the pre-existing basement rock topography during the Miocene era (Stevens et al. 2003). A thin layer of loess caps a majority of the area. Ground water in the area is most commonly found in the basalt and occasionally in the alluvial valley sediments and basement rocks. Ground water generally flows to the north and eventually discharges into the Clearwater River (Hagan 2003). Well depths from ground water sampling ranged from 134 to 1,025 feet.

Limited ground water sampling has also shown elevated nitrate concentrations in the Tammany Creek area. Tammany Creek is located on the south side of the project area, and the watershed has similar spring-fed nutrient load characteristics as the Lindsay Creek watershed on the north side of Lewiston. The ground water in this watershed may also be a potential source of excess nutrients to Tammany Creek. Tammany Creek is currently impaired by nutrients and has an approved nutrient TMDL (DEQ 2010).

DEQ has been collecting data to develop an ambient ground water quality monitoring network monitored on a quarterly basis. Since 2010, this network has included 14 sites. Nitrate concentrations from sampled wells and springs were analyzed to determine if seasonal or spatial trends exist in the monitoring network in addition to monitoring long-term regional changes. Anomalous nitrate concentrations are addressed as isolated or localized situations and dropped from the ambient network, if needed.

2.4.2.2 Methods and Results

A total of 10 wells and 4 springs were included in the 2014 sampling efforts for the Tammany/Lindsey Creek monitoring project. DEQ sampled 10 wells and 4 springs in March; 9 wells and 4 springs in September; and 8 wells and 3 springs in December 2014 (Table 21; Figure 26). Two wells and one spring (696, 1039, and 1311) were not included in all three sampling rounds due to lack of water/low water or access issues.

Water-quality field parameters—temperature, specific conductivity, and DO (March only)—were measured in the field prior to sample collection (Table 21), and samples were collected for nitrate analysis (Figure 26).

Table 21. Water quality field parameters—Tammany Lindsay Ground Water Monitoring Project.

Site ID	Well Depth (feet)	March 2014			September 2014			December 2014		
		Spec. Cond. (µs/cm)	Water Temp. (°C)	DO (mg/L)	Spec. Cond. (µs/cm)	Water Temp. (°C)	DO (mg/L)	Spec. Cond. (µs/cm)	Water Temp. (°C)	DO (mg/L)
533	225	857	11.9	9.49	806	15.3	—	856	9.7	—
538	228	854	12.1	0.62	641	14.1	—	1235	12.6	—
696	295	987	11.9	4.99	984	13.8	—	NS	NS	NS
1038	150	1236	11.3	9.86	1127	13.1	—	1171	10.5	—
1039	235	973	11.6	9.19	NS	NS	NS	NS	NS	NS
1171	Spring	1107	8.3	10.83	1097	16.3	—	1060	7.0	—
1254	197	943	9.1	9.64	850	14.8	—	993	10.3	—
1255	200	878	12.5	8.63	876	14.7	—	883	9.6	—
1311	Spring	1187	10.0	9.96	1185	17.8	—	NS	NS	NS
1312	1025	198.4	12.1	7.81	203	19.8	—	198	15.8	—
1314	Spring	490	7.9	9.44	525	19.3	—	523	8.1	—
1315	476	551	11.3	6.85	569	12.7	—	567	7.9	—
1317	Spring	558	12.4	9.21	561	12.8	—	573	11.2	—
2022	800	227	10.6	3.61	236	20.2	—	229	9.0	—

Notes: (—) indicates data are not available or were not analyzed. NS = not sampled.

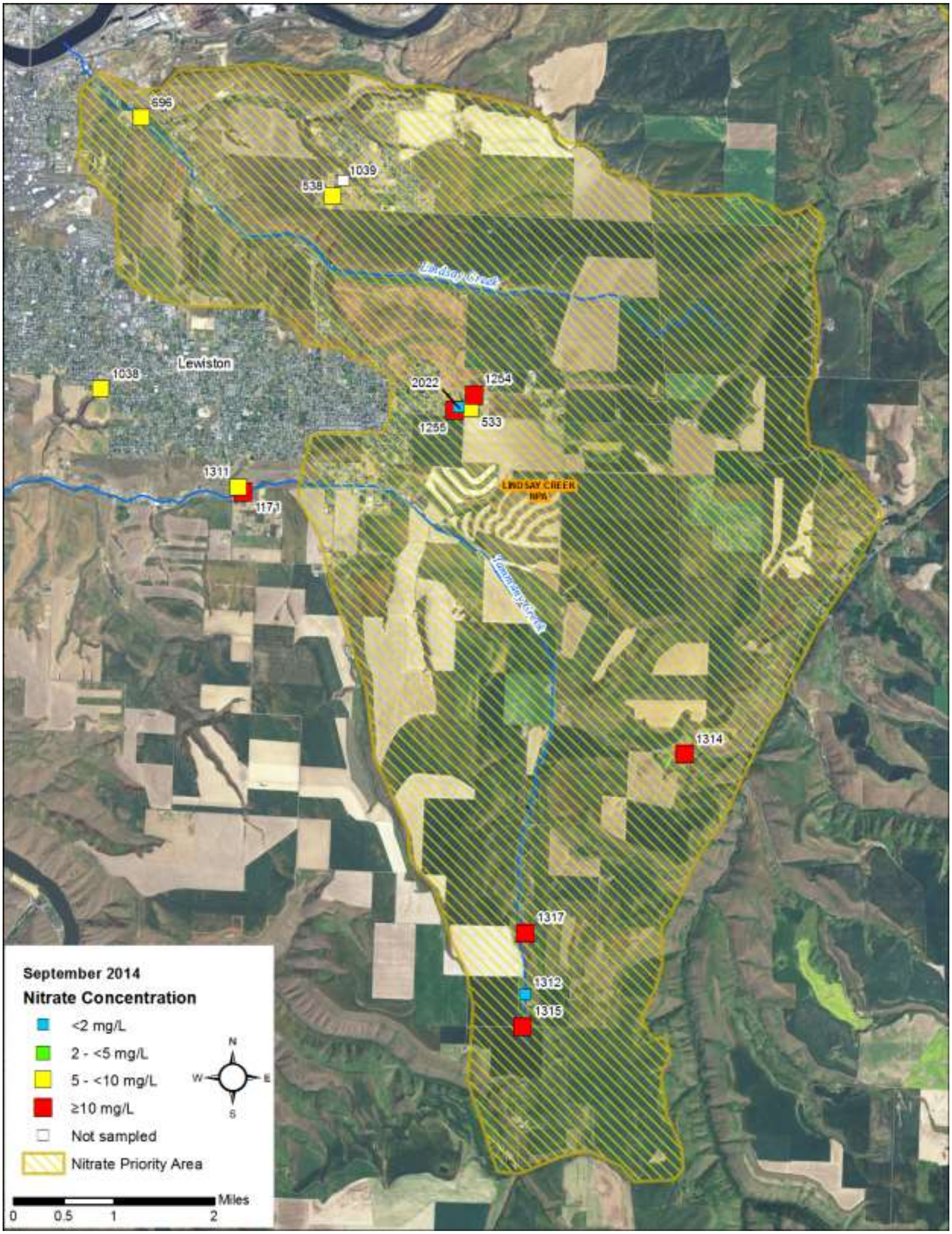


Figure 26. Well (or spring) locations with site identification numbers and nitrate concentrations—Tammany and Lindsay Creeks Ground Water Monitoring Project, September 2014.

Nitrate results from the 2014 sampling are presented in Table 22. The highest nitrate concentration of 15.5 mg/L was observed from a spring at site 1254 during the December 2014 sampling event (Figure 26). In the project area, 9 of the 14 sample sites had nitrate concentrations that exceeded the MCL of 10 mg/L during at least one quarter, and 7 of these sites exhibit mean nitrate concentrations over 10 mg/L for 2014; 6 of the 7 with a mean nitrate concentration over 10 mg/L showed an increase in nitrate concentration from March to December. The most significant increase was in Site 538, with an increase of 11.87 mg/L.

Only sites 1312 and 2022 (well depths of 1025 and 800 feet, respectively) have mean (yearly average) concentrations less than 5 mg/L for the year. Seasonal means across the monitoring network ranged from 8.41 mg/L to 10.17 mg/L. Nitrate concentrations were highest in December and lowest in March.

Table 22. Nitrate results—Tammany Lindsay Ground Water Monitoring Project.

Site ID	Well Depth (Feet)	Nitrate Concentration in milligrams per liter (mg/L)			
		March 2014	September 2014	December 2014	Yearly Average[a]
533	225	**10.6**	9.87	**11.1**	**10.52**
538	228	1.03	5.92	**12.9**	6.62
696	295	6.02	5.18	NS	5.60
1038	150	7.19	7.0	6.91	7.03
1039	235	7.66	NS	NS	—
1171	Spring	**10.5**	**10.2**	**10.1**	**10.27**
1254	197	**12.3**	**11.3**	**15.5**	**13.03**
1255	200	**13.5**	**13.0**	**13.9**	**13.47**
1311	Spring	**10.3**	9.24	NS	9.77
1312	1025	0.341	0.334	0.336	0.34
1314	Spring	**12.7**	**14.1**	**13.3**	**13.37**
1315	476	**11.6**	**12.8**	**12.8**	**12.40**
1317	Spring	**13.9**	**14.1**	**14.9**	**14.30**
2022	800	<0.1	<0.1	<0.1	<0.1
Average		8.41	8.70	10.17	9.02

Notes: Bolded red numbers indicate the US Environmental Protection Agency's maximum contaminant level of 10 mg/L was reached or exceeded. NS = not sampled. (—) = data are unavailable or were not analyzed.
[a] Yearly averages were not calculated for sites that were sampled for less than 2 sampling events.

A histogram of all nitrate samples in the project area for 2014 is shown in Figure 27. A Kruskal-Wallis analysis was performed to test for seasonal differences between the synoptic sampling events across the monitoring area. There is no evidence of significant differences ($p = 0.46$) between the three sampling events in 2014.

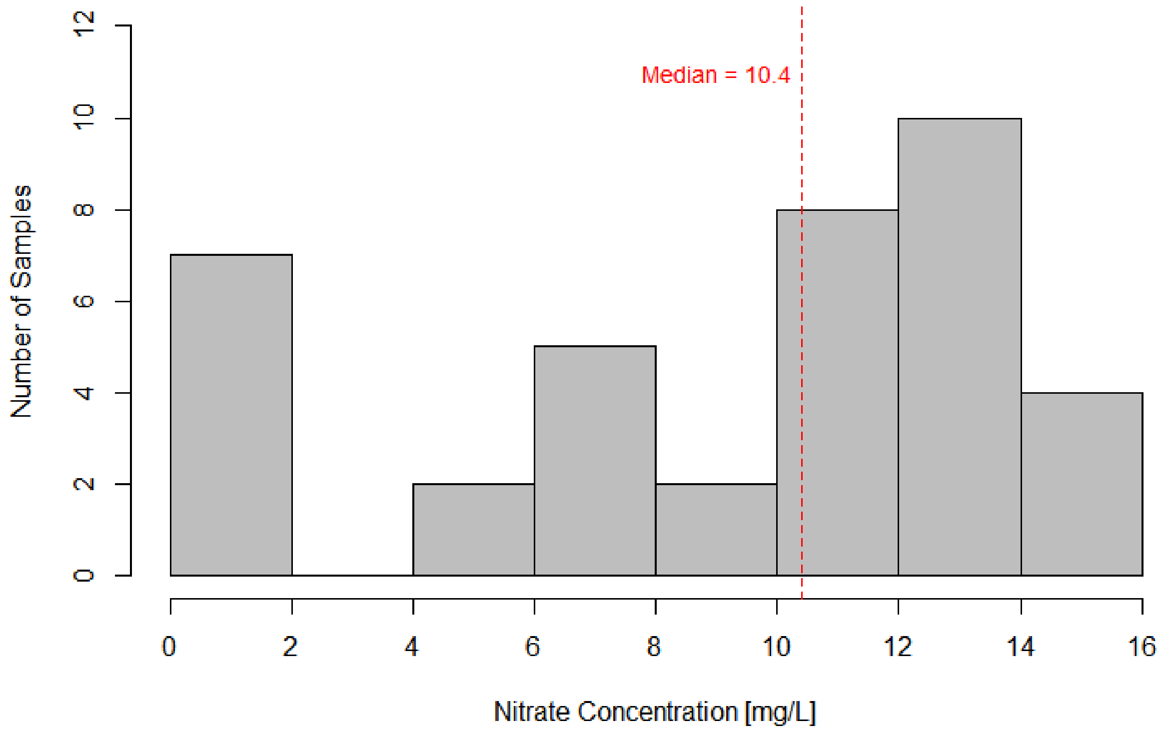


Figure 27. Histogram of nitrate concentrations of all nitrate samples (n = 38)—Tammany/Lindsay Creeks project area, 2014. The median nitrate concentration value exceeds the MCL of 10 mg/L.

Seasonal fluctuations and trends in nitrate concentrations in Tammany/Lindsey Creek wells were also evaluated visually using scatterplots (Figure 28). No seasonality patterns could be determined from the plots.

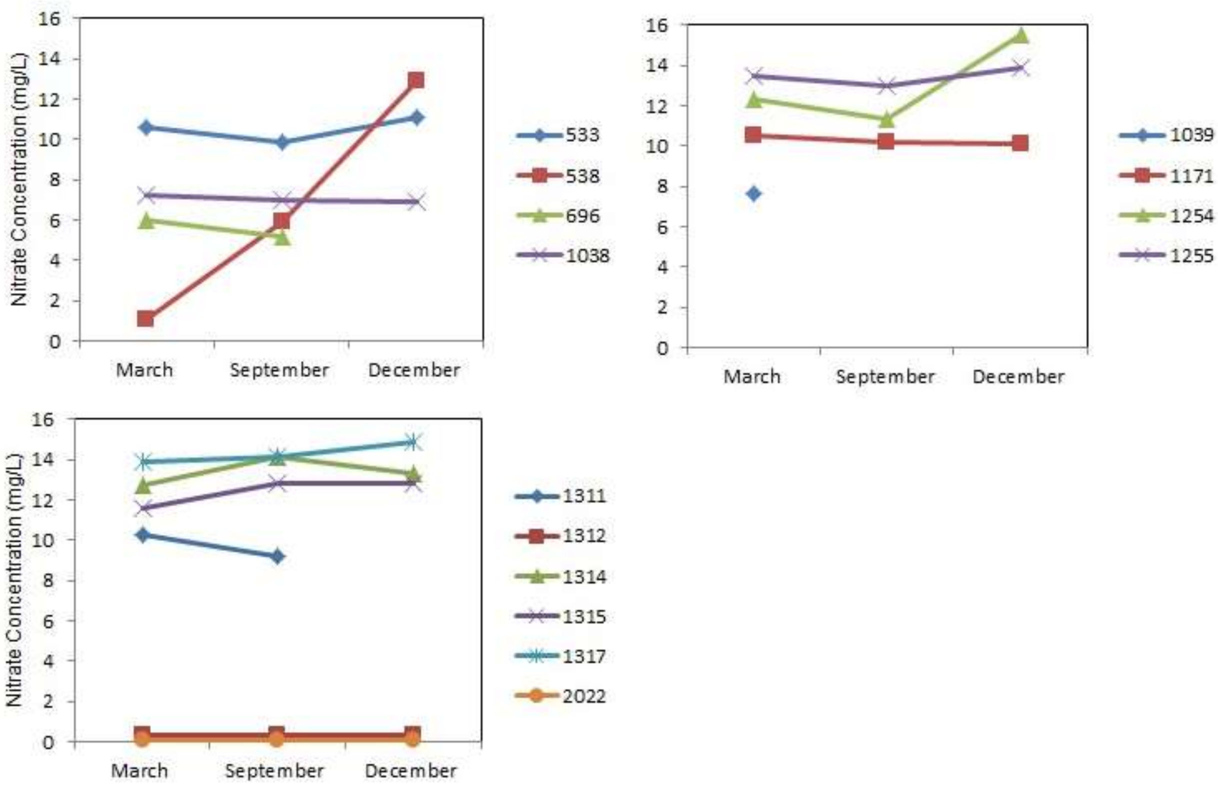


Figure 28. Scatterplots of nitrate concentrations of all nitrate samples—Tammany/Lindsay Creeks project area.

2.4.2.3 Conclusions

The objective of this project is to use an ambient ground water quality monitoring network in the Tammany and Lindsay Creeks area to complete a multiple year seasonal trend analysis. Sampling of wells and springs in the project area during 2014 helped realize this objective. Results show that ground water in the Tammany/Lindsay Creeks project area has elevated nitrate concentrations, with the majority of sample locations exceeding EPA’s MCL of 10 mg/L during at least one sampling event. Wells available to include in an ambient network are limited, and springs shown to be representative of ground water conditions may continue to be added to the monitoring network to satisfy data needs.

Tracking trends in ambient nitrate ground water concentration due to changes in land uses or source controls will be accomplished by comparing seasonal trends over multiple years. This comparison will assist in determining the effects of seasonal variability that occur due to changes in cropping patterns and fertilizer application, variation in nitrogen uptake by crops due to growing season conditions, and variations in leaching rates related to the amount and timing of precipitation that is available to mobilize nitrogen below the crop root zone. Multiple year seasonal trend analysis of ambient nitrate concentrations has not yet been conducted because additional data and compilation are needed prior to conducting such analyses. Data and resources are anticipated to be available to complete the trend analysis phase of the project in the future.

2.4.2.4 Recommendations

Continued monitoring of available wells and springs is recommended to establish an ambient ground water quality data set to track multiple year and seasonal trends, specifically for nitrate, in the project area. Outlier tests and common ion chemistry should be used to determine if samples are representative of ambient conditions and could be used to monitor long-term trends in ground water quality, once sufficient data are collected. Wells yielding sample concentrations or other parameters inconsistent with the ambient conditions should be evaluated to determine if they represent the impacted aquifer. Multiple year trend analysis should be completed to quantify long-term trends in nitrate concentration.

DEQ is drafting an NPA management plan with the assistance of the Lindsay and Tammany Creeks Watershed Advisory Group to address the ground water degradation. The management plan will be a component of the Lindsay Creek TMDL implementation plan. The Nez Perce County Soil and Water Conservation District has proposed funding the plan through Clean Water Act §319 grant funds on two occasions. The NPA management plan and applications for funding should be continued to assist with ground water protection efforts and implementing projects to reduce nitrogen loading.

2.4.3 Cottonwood Creek Nitrate Investigation

2.4.3.1 Purpose and Background

The objective of the Cottonwood Creek nitrate investigation is to increase coverage of nitrate sampling data in domestic wells along the eastern border of the Lapwai Creek NPA. Data used to delineate the boundaries of the NPA were collected from 2008 to 2011 by the IDWR Statewide Monitoring Network. Located in Nez Perce County, the Lapwai Creek NPA ranked 27th of 34 NPAs in the state in 2014 and is one of three NPAs located within jurisdiction of the DEQ Lewiston Regional Office. The NPA covers 53 square miles (34,214 acres). It is located within the Nez Perce Reservation, east of Lapwai, South of Highway 12, extending slightly south of the town of Culdesac (Figure 29).

The investigation was designed to increase coverage of ground water quality data for nitrate surrounding the highest nitrate reading from the 2014 delineation of the Lapwai Creek NPA—a 2011 value of 10.3 mg/L at the eastern tip of the NPA. Due to lack of sample sites east of the 10.3 mg/L reading, it was unknown if nitrate contamination extended east of the NPA. The primary purpose of the investigation was to determine if this nitrate detection, at the eastern border of the NPA, was an isolated detection (point source), or if high nitrate concentrations exist over a larger area, possibly outside the NPA border. The data collected for the investigation will be used to evaluate nitrate concentrations in ground water within the project boundaries. The data may also be used in review of future NPA delineation (DEQ 2013f).

The project area was determined by using the elevated nitrate well located at the eastern tip of the Lapwai Creek NPA as the target site to be positioned at the center of the investigation area that radiates out approximately 6 miles from that point (Figure 29).

The project area lies within the Clearwater Embayment, which is the easternmost portion of the Columbia River Basalt Flows (Hagan 2003). The Clearwater Embayment consists of basalt units that formed when lava flows filled in the pre-existing basement rock topography during the Miocene era (Stevens et al. 2003). The basement rocks consist of volcanics associated with the Seven Devils Complex, granitoids associated with the Idaho Batholith, and metasedimentary units associated with the Belt Supergroup (Hagan 2003). A majority of the area is capped with a thin layer of loess.

Ground water in the project area is most commonly found in the basalt aquifers and occasionally in the alluvial valley aquifers and basement rocks. More specifically, ground water occurs in fractures in the rock bodies, pore spaces of sedimentary material, and interflow zones of basalt flows (Castelin 1976). Unconfined and confined conditions are found in both the regional and local flow systems. The regional direction of ground water flow is from higher elevations in the southern and southeastern sections of the project area toward the north, where ground water eventually discharges into the Clearwater River (Hagan 2003). Depths of wells included in the project range from 26 to 850 feet bgs.

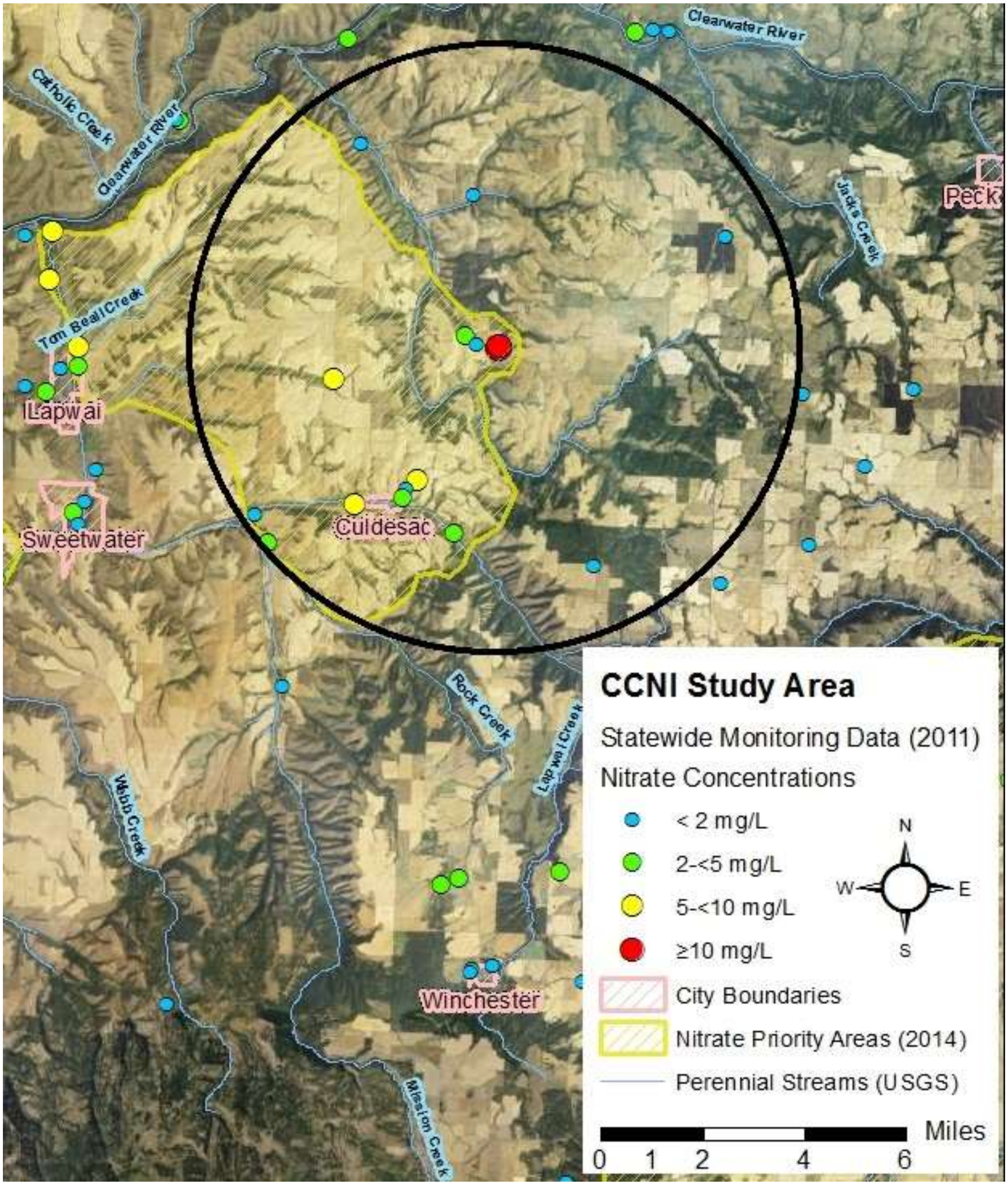


Figure 29. Study area showing target site well (red) as center of investigation area—Cottonwood Creek nitrate investigation. Nitrate results are from 2011 monitoring data.

2.4.3.2 Methods and Results

DEQ sampled a total of 26 domestic wells and 1 spring in and around the eastern border of the NPA during April, May, October, and November 2014 using methods described in the specific project FSP (DEQ 2014k) (Figure 30). A total of 5 of these sites were resampled in November.

The deviation from the QAPP (DEQ 2013f) in sample site selection methods were a result of a lack of available driller's reports and limited potential sample sites in the area. Rather than using driller's logs to choose sample sites, the investigation sites were selected based on location in relation to the target site and owner willingness to participate in the study. Available well log information was gathered, and well owners were surveyed about information regarding their well. Deviations from the parent QAPP are described in detail in the specific project FSP.

Sample sites were selected with respect to proximity to the target site (Well 2406) and distribution within the target area; locations were based on an increasing radius moving away from the target site (Figure 30). This pattern allows measurements close to the target area to be closer together, while sample sites are farther apart as distance from the target increases. The target site had a nitrate concentration of 10.3 mg/L in 2011, based on a sample collected by IDWR in the SMN. To simulate an increasing radial pattern, three circles were drawn around the target site. Each circle was divided into different subsections, increasing in size as distance from the target increased. Site selection by location was focused on finding at least one well to sample inside of each subsection. All samples are within 6 miles of the target site.

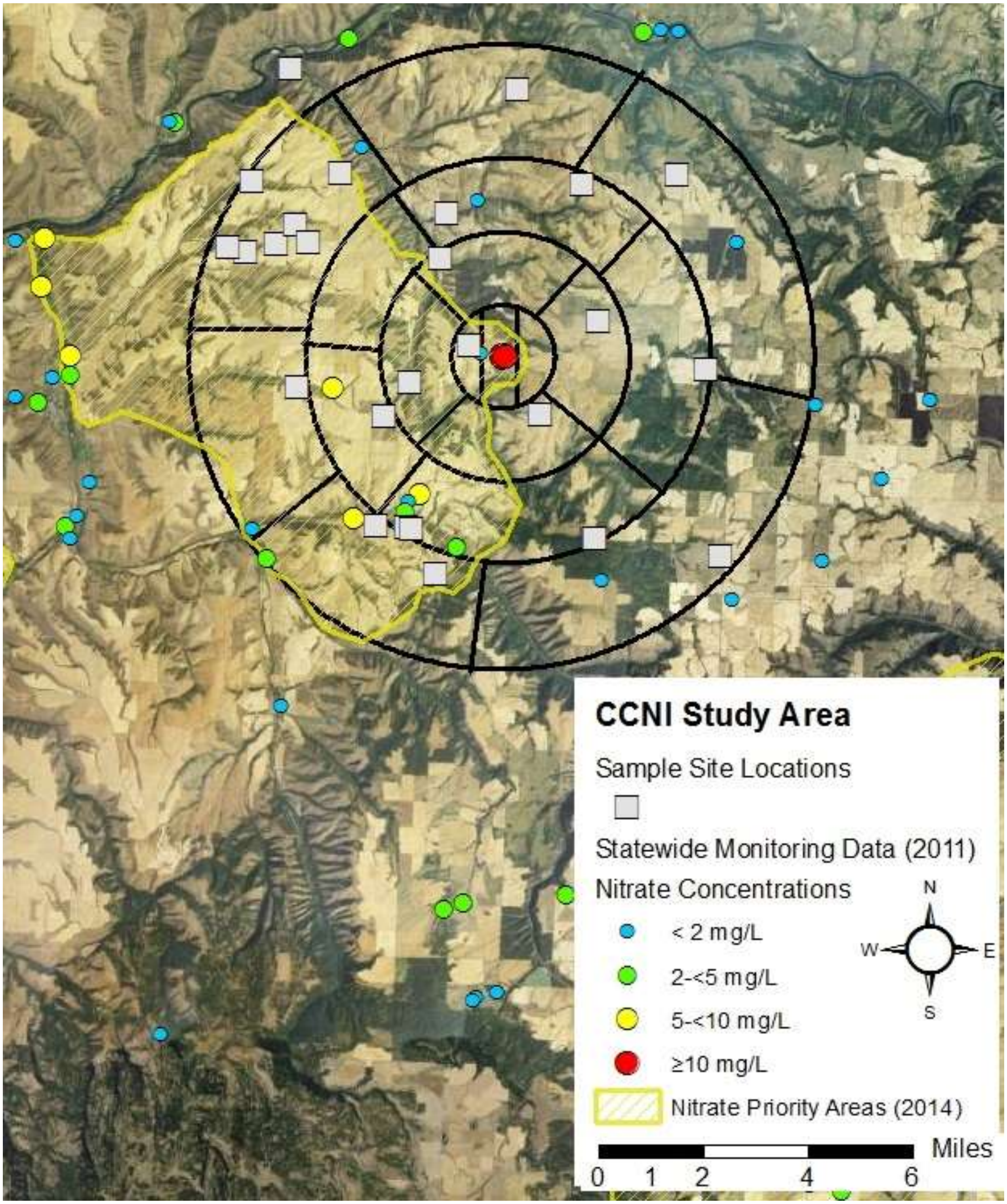


Figure 30. Study area subsections and sample site locations—Cottonwood Creek Nitrate Investigation.

Samples were collected and analyzed for nitrate, bacteria, and either major ions or common anions (bromide, chloride, fluoride, otho-phosphorus, and sulfate). Samples were also collected for bacteria (*E. coli*) analysis as a way to evaluate the potential for influence from a septic system, in the event nitrate levels were elevated. Major ions were tested as an alternate way of determining the source of water sampled. All samples were sent to Anatek Labs in Moscow, Idaho, for analysis.

Water samples were collected throughout 2014, with sampling occurring in April, May, October, and November. A total of 10 wells were sampled in late April and early May, and the remaining 15 sites (14 wells and one spring) were sampled in October. In November, 2 additional wells were sampled and several October sites were resampled. The April/May and October samples were field tested for temperature, conductivity, and dissolved oxygen (DO) and lab-tested for nitrate, bacteria, and inorganic anions. When results were obtained from Anatek labs, 5 of the sites sampled in October were randomly selected for further analysis. The 5 sites were resampled in November and analyzed for nitrate and major ions so a water type/chemistry analysis (using a Piper diagram) could be conducted. At that time, 2 new sites were sampled for nitrate only. Table 23 presents water quality field parameters and major ions results and Table 24 presents the nitrate and bacteria results.

Table 23. Water quality field parameter and inorganic ion results—Cottonwood Creek nitrate investigation.

DEQ Site ID	Well Depth (feet)	Sample Date	Field Measurements			Major Ions										
			Water Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Calcium	Magnes-ium	Sodi-um	Potas-sium	Bicarbo-nate	Carbo-nate	Fluo-ride[a]	Chlor-ide[b]	Bro-mide	Ortho-phosphate	Sul-fate[b]
						(mg/L)										
Primary or Secondary Standard:						*NA*	*NA*	*NA*	*NA*	*NA*	*NA*	*4*	*250*	*NA*	*NA*	*250*
2406	—	10/29/14	12.2	353	—	—	—	—	—	—	—	0.31	9.42	0.207	0.18	16
		11/21/14	8.3	476	—	54.4	19.3	19.3	5.4	94.2	<5	—	64.1	—	—	22.8
2407	250	10/30/14	14.6	215	—	—	—	—	—	—	—	0.33	1.28	<0.1	0.137	3.57
2408	26	10/29/14	15.2	231	—	—	—	—	—	—	—	<0.1	0.392	<0.1	<0.1	9.84
		11/21/14	10.8	227	—	28.3	6.2	8.58	0.381	28.3	<5	—	<0.5	—	—	9.58
2409	—	10/30/14	12.9	193	—	—	—	—	—	—	—	0.347	1.39	<0.1	0.14	2.25
2410	125	10/29/14	14.6	167.9	—	—	—	—	—	—	—	0.143	1.31	<0.1	0.164	5.3
2411	150	10/30/14	13	335	—	—	—	—	—	—	—	0.334	2.56	<0.1	0.152	6.6
		11/21/14	11.8	336	—	38.9	15.5	14.2	4.49	38.9	<5	—	2.67	—	—	6.67
2412	Spring	10/30/14	13.5	187.1	—	—	—	—	—	—	—	0.163	0.869	<0.1	0.181	5.38
2413	—	10/29/14	12	216.1	—	—	—	—	—	—	—	0.242	0.889	<0.1	0.16	5.24
2414	850	10/29/14	15.5	269	—	—	—	—	—	—	—	0.244	0.832	<0.1	<0.1	37.1
2415	—	10/29/14	12.4	375	—	—	—	—	—	—	—	0.215	1.01	<0.1	0.121	12.4
		11/21/14	8.2	383	—	45.8	14.1	24.6	1.85	45.8	<5	—	1.01	—	—	12.8
2416	—	10/29/14	12.3	342	—	—	—	—	—	—	—	0.261	1.05	<0.1	0.155	7.31
		11/21/14	13.7	342	—	40.7	13.2	20.2	2.33	40.7	<5	—	1.05	—	—	7.33
2417	350	10/30/14	14	312	—	—	—	—	—	—	—	0.254	2.1	<0.1	<0.1	6.98
2418	—	10/29/14	13.3	420	—	—	—	—	—	—	—	0.383	4.82	<0.1	0.126	16.2
2419	690	10/29/14	13.1	185	—	—	—	—	—	—	—	0.233	0.696	<0.1	0.131	7.26
2420	—	10/29/14	11.3	337	—	—	—	—	—	—	—	0.264	1.32	<0.1	<0.1	19.2
2421	—	4/28/14	14.4	359	9.3	—	—	—	—	—	—	0.356	3.38	<0.1	0.183	33
2422	—	5/7/14	11.7	368	—	—	—	—	—	—	—	0.43	2.19	<0.1	<0.1	9.21

DEQ Site ID	Well Depth (feet)	Sample Date	Field Measurements: Water Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	Major Ions (mg/L): Calcium	Magnes-ium	Sodi-um	Potas-sium	Bicarbo-nate	Carbo-nate	Fluo-ride[a]	Chlor-ide[b]	Bro-mide	Ortho-phosphate	Sul-fate[b]
Primary or Secondary Standard:						***NA***	***NA***	***NA***	***NA***	***NA***	***NA***	***4***	***250***	***NA***	***NA***	***250***
2423	–	4/3/14	15.2	318	1.13	–	–	–	–	–	–	0.501	3.41	<0.1	<0.1	7.61
2424	–	4/3/14	12.5	417	7.01	–	–	–	–	–	–	0.436	1.86	<0.1	0.132	11.6
2425	–	4/3/14	7.6	512	8.95	–	–	–	–	–	–	0.521	2.68	<0.1	0.103	19.9
2426	–	5/7/14	12.5	502	–	–	–	–	–	–	–	0.566	7.94	<0.1	<0.1	13.1
2427	380	5/7/14	9.8	513	–	–	–	–	–	–	–	0.459	2.59	<0.1	0.239	25.3
2428	188	4/28/14	19.6	873	–	–	–	–	–	–	–	0.423	3.61	<0.1	0.108	6.51
2429	350	4/28/14	14.6	199.4	0.8	–	–	–	–	–	–	0.324	0.66	<0.1	0.127	4.51
2430	–	11/21/14	7.1	446	–	–	–	–	–	–	–	–	–	–	–	–
2431	–	11/21/14	9.6	153	–	–	–	–	–	–	–	–	–	–	–	–
2433	–	5/7/14	11.2	374	–	–	–	–	–	–	–	0.364	1.13	0.239	0.13	22.1

Notes: National Primary and Secondary Drinking Water Regulation standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality. (–) = data are unavailable or were not analyzed.
[a] Contaminant with a National Primary Drinking Water Regulation standard.
[b] Contaminant with a National Secondary Drinking Water Regulation standard.

Table 24. Nitrate and bacteria results—Cottonwood Creek Nitrate Investigation Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Nitrate (mg/L)	*E. coli*[a] (MPN/100 mL)
Primary Standard:			***10***	***<1 cfu/100 mL***
2406	–	10/29/14	**13.3**	<1.0
		11/21/14	**10.0**	–
2407	250	10/30/14	1.68	<1.0
2408	26	10/29/14	**16.4**	<1.0
		11/21/14	**15.7**	–
2409	–	10/30/14	0.356	<1.0
2410	125	10/29/14	1.41	<1.0
2411	150	10/30/14	6.69	<1.0
		11/21/14	6.7	–
2412	Spring	10/30/14	2.86	**4.1**
2413	–	10/29/14	0.902	<1.0
2414	850	10/29/14	<0.1	<1.0
2415	–	10/29/14	8.89	<1.0
	–	11/21/14	8.41	–
2416	–	10/29/14	7.66	**1.0**
	–	11/21/14	7.35	–
2417	350	10/30/14	<0.1	<1.0
2418	–	10/29/14	**13.1**	<1.0
2419	690	10/29/14	1.59	**1.0**
2420	–	10/29/14	<0.1	<1.0
2421	–	4/28/14	**14.0**	**1.0**
2422	–	5/7/14	6.61	<1.0
2423	–	4/3/14	0.552	<1.0
2424	–	4/3/14	**12.4**	<1.0
2425	–	4/3/14	**17.5**	<1.0
2426	–	5/7/14	**16.6**	<1.0
2427	380	5/7/14	**16.4**	<1.0
2428	188	4/28/14	7.1	<1.0
2429	350	4/28/14	0.164	<1.0
2430	–	11/21/14	**13.0**	–
2431	–	11/21/14	1.16	–
2433	–	5/7/14	**18.8**	<1.0

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality. (–) = data are unavailable or were not analyzed.
[a] Total coliform (TC) results were not provided with the *E.coli* results; however, TC can be interpreted as equal to or greater than *E. coli* concentrations since *E. coli* are a type of TC. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

Ground Water Chemistry

Major ion chemistry was collected to compare chemical composition of the water samples. Differences in major ion chemistry can represent distinct recharge sources, aquifer types, transport times, or chemical processes along the flow path. Sample results are listed in Table 23 and plotted in Figure 31. The samples appear generally similar and representative of shallow, calcium bicarbonate type waters.

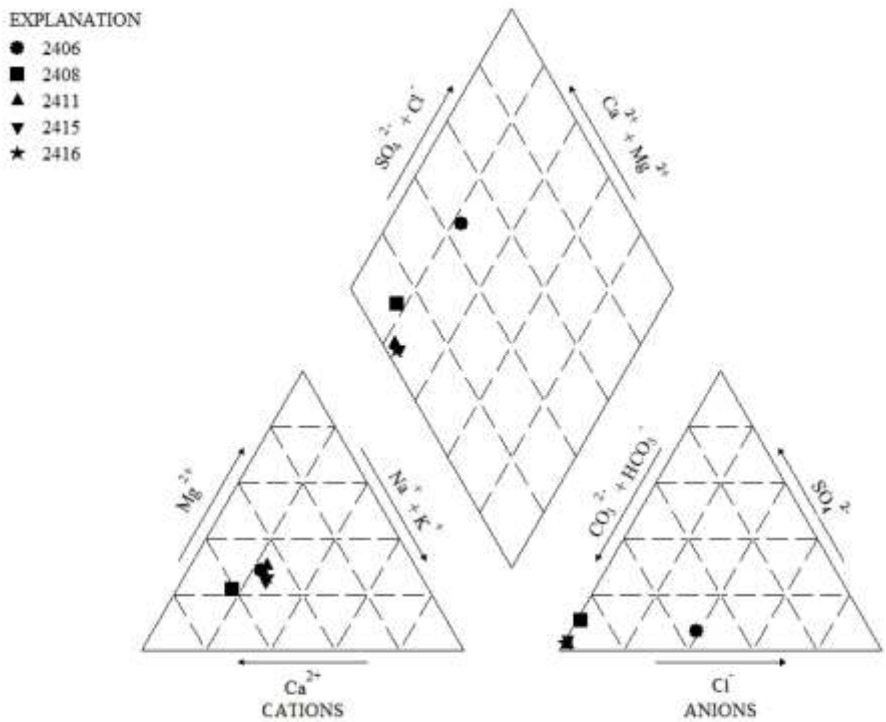


Figure 31. Piper diagram showing major ion chemistry for water samples collected—Cottonwood Creek nitrate investigation. Values are percentage of total milliequivalents per liter.

Nitrate Results

Of the 27 sites sampled for nitrate, 10 sample sites (37%) had nitrate concentrations greater than or equal to the MCL of 10 mg/L; 5 samples (18.5%) had nitrate concentrations greater than 5 mg/L and less than 10 mg/L. Nitrate concentration results are presented graphically in Figure 32.

Bacteria Results

Samples from 25 of the 27 sites were analyzed for bacteria (*E. coli*) during the first time the site was sampled. Four of the 25 samples (2412, 2416, 2419, and 2421) had positive detections of *E. coli*; 3 of the sites with a positive detection had a concentration of 1.0 MPN/100 mL, while the fourth site (2412) had a concentration of 4.1 MPN/100 mL. Site 2412 is a spring not used as drinking water. Total coliform (TC) was not reported by the lab; however, since *E. coli* is a type of coliform and included in the TC count, it can be assumed that TC is equal to or greater than the reported *E. coli* concentrations.

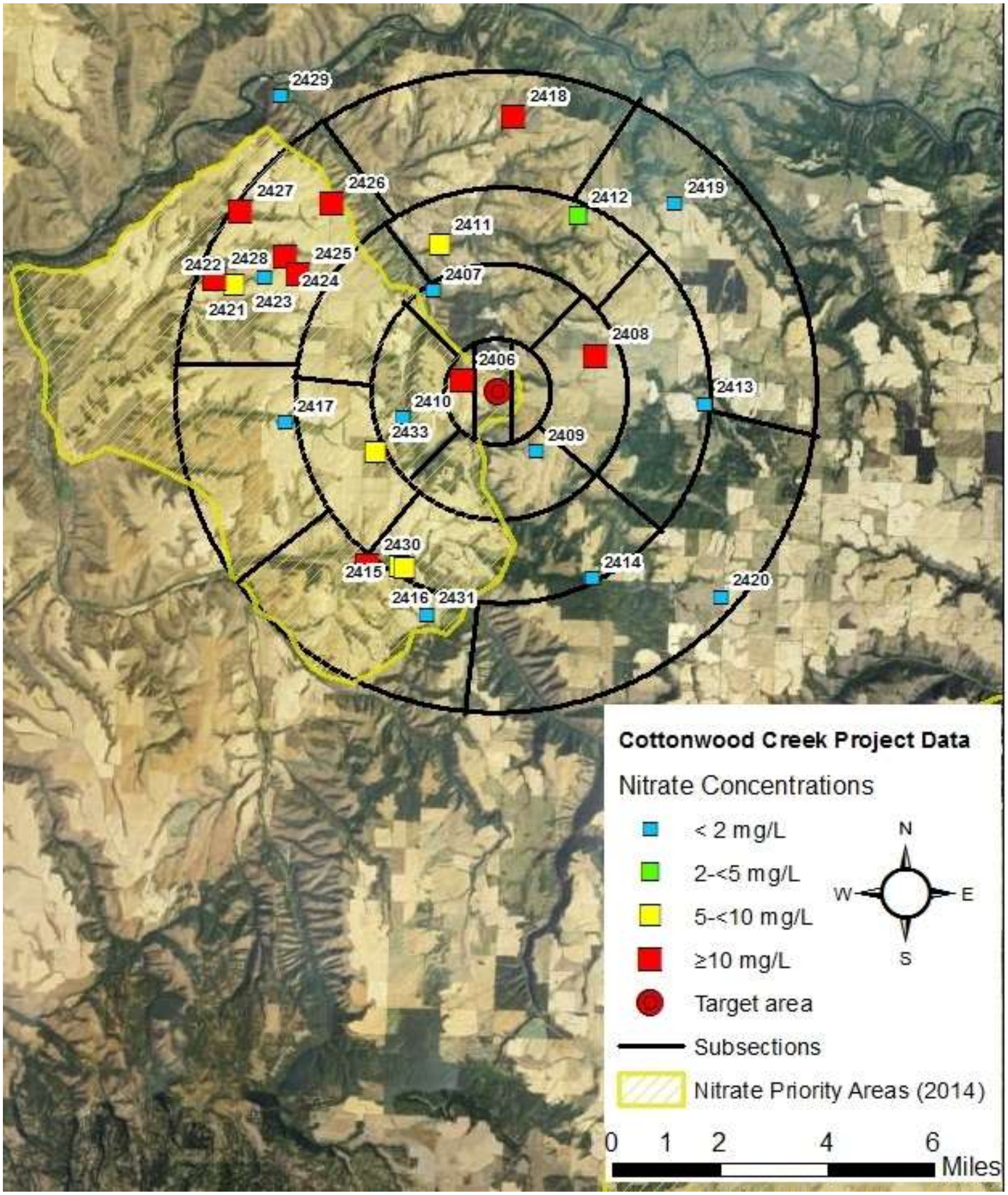


Figure 32. Well (or spring) locations with site identification numbers and nitrate concentrations—Cottonwood Creek nitrate investigation.

2.4.3.3 Conclusions

The goal of this study was to increase spatial distribution of nitrate data in and around the eastern section of the NPA. This objective was met by sampling 26 wells and 1 spring within 6 miles of the target location.

Results from this study confirm elevated nitrate concentrations within the Lapwai Creek NPA boundary and identify elevated levels to the northeast of the NPA where elevated concentrations were not previously known. Areas southeast of the NPA did not show elevated levels of nitrate contamination. Combining information from this study, plus the data from the Statewide Monitoring Network, provides a new perspective for localized nitrate studies.

2.4.3.4 Recommendations

These data can be used to determine if a new NPA delineation area and ranking is needed for the Lapwai Creek NPA. Currently, there are no regional ground water monitoring projects conducted by the LRO within the NPA. Following results from this study, and possibly a new NPA delineation, it may be determined that follow-up ground water monitoring projects should be pursued within the NPA.

This information will be provided to the Nez Perce Soil and Water Conservation District to provide incentive to pursue best management practices in agriculture and land use techniques to address nonpoint source pollution issues for ground water in the Cottonwood Creek area.

2.5 Pocatello Region

One ground water quality monitoring project was conducted in the Pocatello region in 2014 using public funds.

2.5.1 Pocatello Regional Office Ambient Ground Water Monitoring Project

2.5.1.1 Purpose and Background

In 1976, the United States Geological Survey undertook a broad study of ground water quality in southeastern Idaho (Seitz and Norvitch 1979). The study sampled 103 wells in Bannock, Bear Lake, Caribou, and Power Counties (Figure 33) and described the general water quality conditions in the study area. This data set represents a valuable historical reference, against which current conditions can be compared.

The multi-year Pocatello Regional Office (PRO) Ambient Ground Water Quality Monitoring Project is designed to provide the data necessary for evaluating ambient ground water quality in portions of Bannock, Bear Lake, Caribou, and Power Counties. Ground water samples will be collected from the same wells previously examined by Seitz and Norvitch (1979), allowing for direct comparison with historical conditions. Data gathered through this project will assist in characterizing current ground water conditions, identifying areas and possible sources of degraded ground water quality, and evaluating changes in water quality over time. Continuing the work started by Seitz and Norvitch, the data collected will also provide a reference for future sampling.

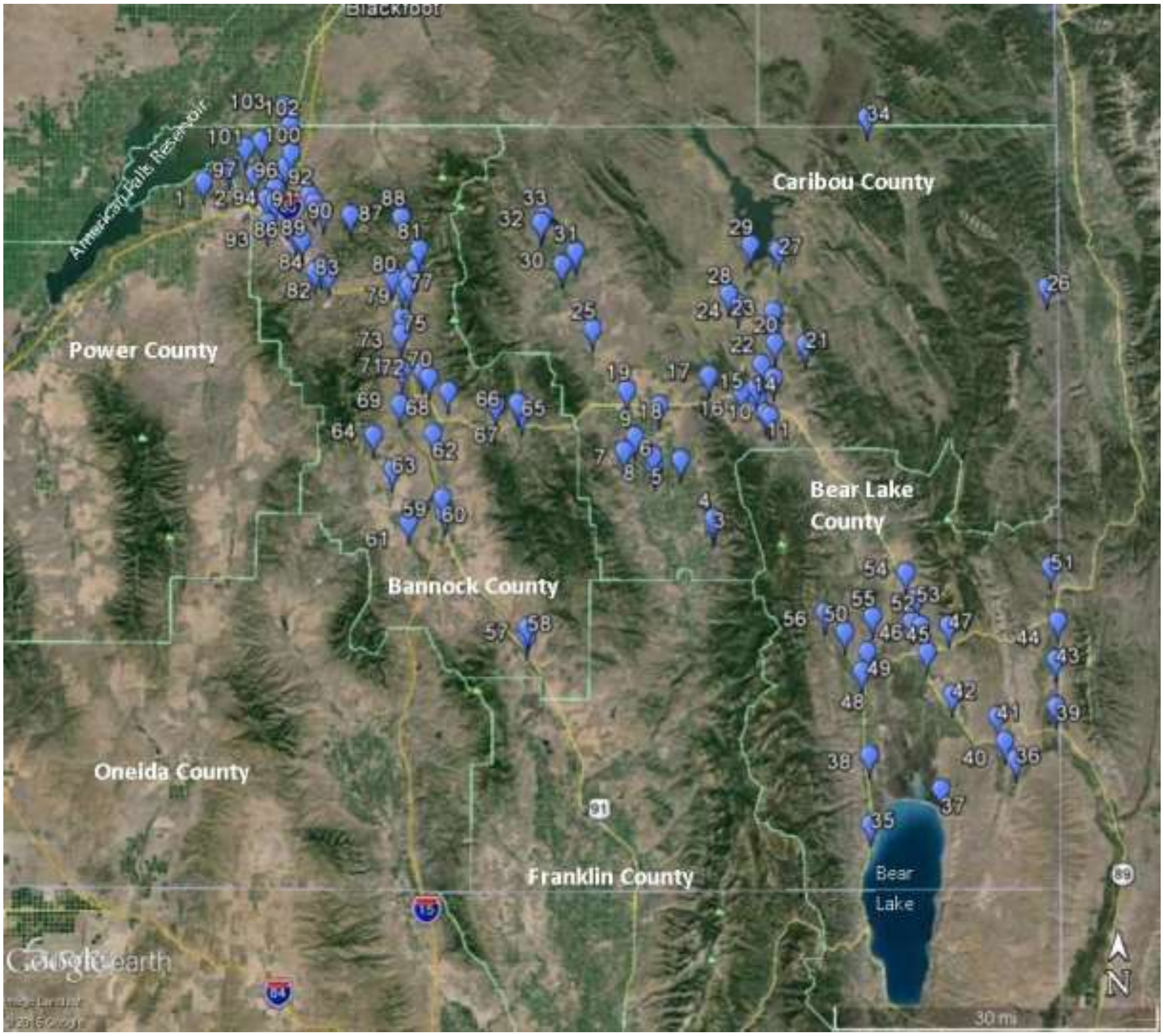


Figure 33. 2014 Google Earth map of approximate locations of 103 wells from Seitz and Norvitch study (1979).

2.5.1.2 Methods and Results

Sample sites for the project were identified using information from Seitz and Norvitch (1979). To maintain consistency with that study, sampling was limited to July through September. Each year, a portion of the original wells are investigated for potential resampling, with the entire inventory expected to be investigated within 5 years. In September 2014, 10 wells were sampled in Bear Lake County (Figure 34) in accordance with procedures outlined in DEQ (2011b) and DEQ (2014g).

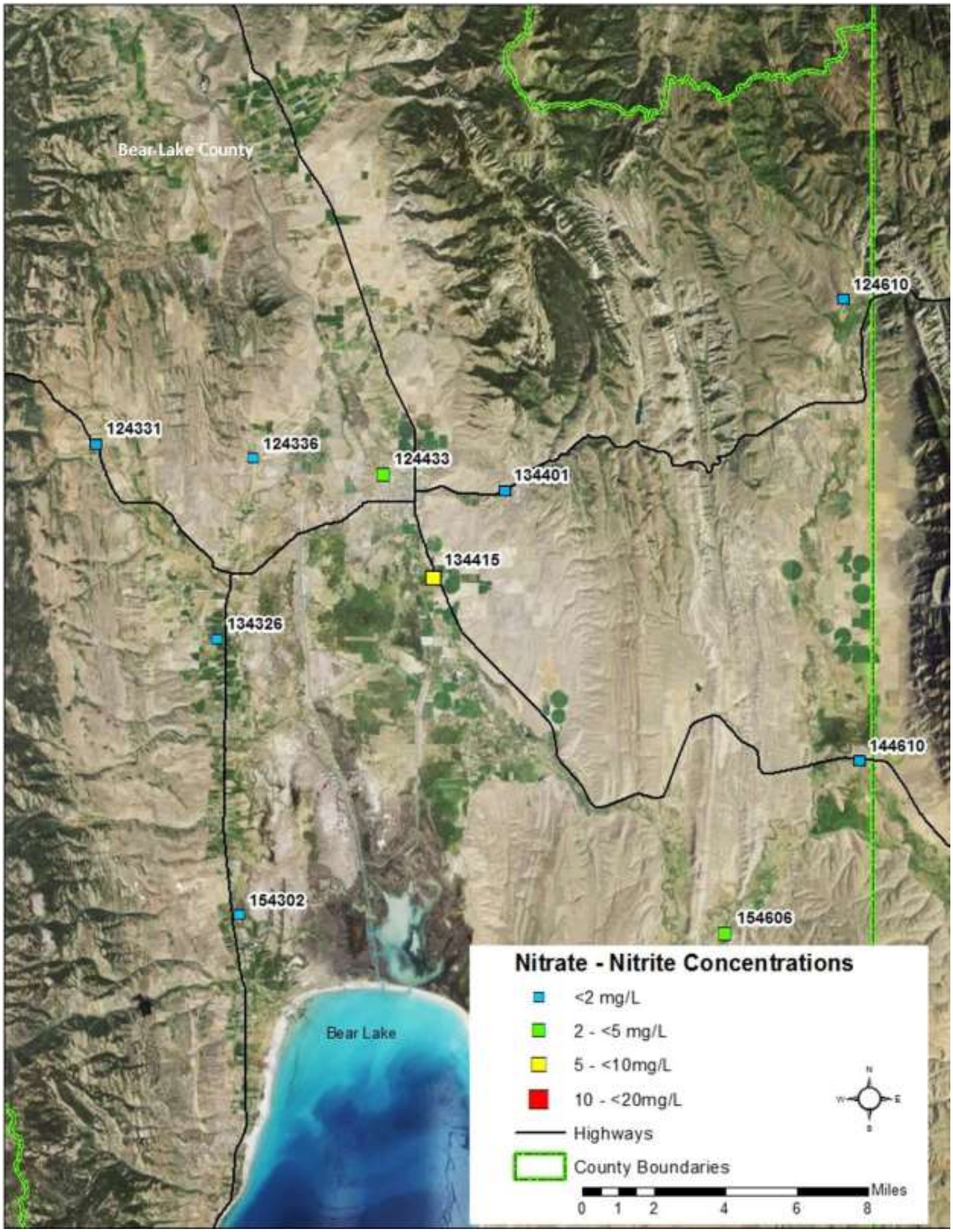


Figure 34. Well locations, names, and nitrate concentrations for September 2014 sampling—PRO Ambient Ground Water Quality Monitoring Project.

Water quality field parameters, including temperature, specific conductivity, pH, and dissolved oxygen, were measured in the field (Table 25) prior to sampling to ensure the well was properly purged and the samples would be representative of aquifer conditions. Samples were submitted to IBL for analysis. Water chemistry analyses included calcium, magnesium, sodium, potassium, chloride, sulfate, alkalinity, arsenic, fluoride, silica, nitrite plus nitrate, ammonia, and total phosphate. Samples were also analyzed at IAS Envirochem in Pocatello for total coliform and *E. coli* bacteria. Stable isotopes of oxygen and hydrogen ($\delta^{18}O_{H2O}$ and δD_{H2O}) were measured at the University of Arizona Laboratory of Isotope Geochemistry, and samples with a lab-specified minimum nitrate concentration of 0.07 mg/L were submitted to the Northern Arizona University–Colorado Plateau Stable Isotope Laboratory for quantification of $\delta^{15}N_{nitrate}$ and $\delta^{18}O_{nitrate}$. Results of the analyses for major ions are presented in Table 26, while additional inorganic constituents, nutrients, isotopes, and bacteria results are presented in Table 27.

Table 25. Water quality field parameters—PRO Ambient Ground Water Monitoring Project.

DEQ Site ID	Project Well Name	Well Depth (feet)	Sample Date	Field Measurements			
				Water Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH[a]
2438	154606	38	9/16/2014	8.64	920	1.39	7.12
2446	154302	50	9/17/2014	8.82	463	1.2	7.41
2447	144610	108	9/16/2014	9.6	965	5.8	7.3
2448	134415	72	9/16/2014	12.1	771	5.71	7.07
2449	134401	75	9/16/2014	8.58	1030	3.38	7.02
2450	134326	82	9/23/2014	9.3	470	4.1	7.32
2451	124610	128	9/23/2014	8.12	506	9.68	7.09
2452	124433	52	9/17/2014	8.83	599	6.43	7.23
2453	124336	73	9/17/2014	10.46	395	1.16	7.47
2454	124331	92	9/17/2014	10.05	511	4.48	6.99

[a] Contaminant with a National Secondary Drinking Water Regulation standard. The NSDWR for pH is 6.5–8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Table 26. Major ions—PRO Ambient Ground Water Monitoring Project.

DEQ Site ID	Project Well Name	Well Depth (feet)	Sample Date	Major Ion Concentrations (mg/L)						
				Calcium	Magne-sium	Sodium	Potas-sium	Chloride[a]	Sulfate[a]	Alkalinity (as $CaCO_3$)
Primary or Secondary Standard:				***NA***	***NA***	***NA***	***NA***	***250***	***250***	***NA***
2438	154606	38	9/16/2014	90	41	48	8.3	69.5	90.6	291
2446	154302	50	9/17/2014	43	20	32	1.5	14.9	<0.80	227
2447	144610	108	9/16/2014	120	51	25	1.8	30.6	*338*	171
2448	134415	72	9/16/2014	84	34	26	6.2	59.3	64.9	240
2449	134401	75	9/16/2014	140	52	15	1.1	19.8	*358*	215
2450	134326	82	9/23/2014	69	18	15	2.4	12.7	19.8	225
2451	124610	128	9/23/2014	85	15	16	0.86	7.88	26.6	252
2452	124433	52	9/17/2014	88	24	9.6	1.2	10	68.8	232
2453	124336	73	9/17/2014	37	18	18	8.7	7.52	15.1	185
2454	124331	92	9/17/2014	79	19	13	0.62	9.25	10.8	256

Notes: Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality. NA = Not Applicable.
[a] Contaminant with a National Secondary Drinking Water Regulation standard.

Table 27. Nutrient, isotope, and bacteria results—PRO Ambient Ground Water Monitoring Project.

DEQ Site ID	Project Well Name	Well Depth (feet)	Sample Date	Inorganic and Nutrient Concentrations						Isotopes				Bacteria[b]	
				Arsenic[a]	Fluoride[a]	Silica as SiO_2	Nitrite plus Nitrate[a]	Ammonia	Total Phosphate	$\delta^{15}N_{nitrate}$	$\delta^{18}O_{nitrate}$	δD_{H2O}	$\delta^{18}O_{H2O}$	Total Coliform	E. coli
				(ug/L)	(mg/L)					(‰)				(MPN/100 mL)	
Primary or Secondary Standard:				***10***	***4***	***NA***	***10***	***NA***	***NA***	***NA***				***1 cfu/ 100 mL***	***<1 cfu/ 100 mL***
2438	154606	38	9/16/2014	<2.0	<0.20	14	4.3	<0.01	0.013	25.26	6.38	-127	-16.4	<1	<1
2446	154302	50	9/17/2014	**32.4**	0.37	24	<0.01	3.1	0.35	—	—	-144	-18.9	<1	<1
2447	144610	108	9/16/2014	5.4	<0.20	19	0.59	<0.01	0.025	7.38	-7.29	-139	-18.2	<1	<1
2448	134415	72	9/16/2014	2.7	0.705	29	6.2	<0.01	0.019	5.42	-4.36	-130	-16.6	<1	<1
2449	134401	75	9/16/2014	<2.0	0.372	15	0.19	<0.01	0.007	6.19	-7.18	-137	-18.1	<1	<1
2450	134326	82	9/23/2014	3.1	0.243	32	1.9	<0.01	0.049	6.67	-5.57	-133	-17.5	<1	<1
2451	124610	128	9/23/2014	<2.0	<0.20	21	0.035	<0.01	0.075	—	—	-137	-17.9	<1	<1
2452	124433	52	9/17/2014	<2.0	<0.20	14	3	<0.01	0.015	5.64	-6.16	-129	-17	<1	<1
2453	124336	73	9/17/2014	2.3	0.476	45	0.27	<0.01	0.027	7.17	-5.37	-147	-19.3	2	<1
2454	124331	92	9/17/2014	<2.0	0.505	36	1.4	<0.01	0.054	8.81	-5.34	-129	-17.3	<1	<1

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was exceeded. These regulations are applicable for public water systems only but are recommended limits and can be applied to private wells to evaluate water quality. NA = Not Applicable; (—) = data are unavailable or were not analyzed.

[a] Contaminant with a National Primary Drinking Water Regulation standard.

[b] Total coliform and *E. coli* standards are from the Idaho Ground Water Quality Rule (IDAPA 58.01.11.200). An exceedance of the primary ground water quality standard for total coliform (indicated by gray shaded cells) is not a violation of these rules. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Although the standards are given in cfu/100 mL, analytical results provided in MPN/100 mL are acceptable for comparison to the standard.

General Ground Water Chemistry

Primary or secondary drinking water standards were exceeded at three sites. Sulfate concentrations at wells 134401 and 144610 exceeded the aesthetically based secondary drinking water standard of 250 mg/L, while the arsenic concentration at well 154302 exceeded the primary drinking water standard of 10 μg/L (Table 26 and Table 27). A more detailed discussion of the arsenic detection is provided below in the Arsenic Results section below.

Figure 35 illustrates the general major ion chemistry of the samples. The Piper diagram (trilinear plot) shows that calcium and bicarbonate are the predominant ions in most of the sampled wells, while in two wells, 134401 and 144610, sulfate is the primary anion. Both of those wells are located very near surface water and may be significantly influenced by those sources. Two other wells, 134415 and 154606, exhibit significant chloride and sulfate concentrations.

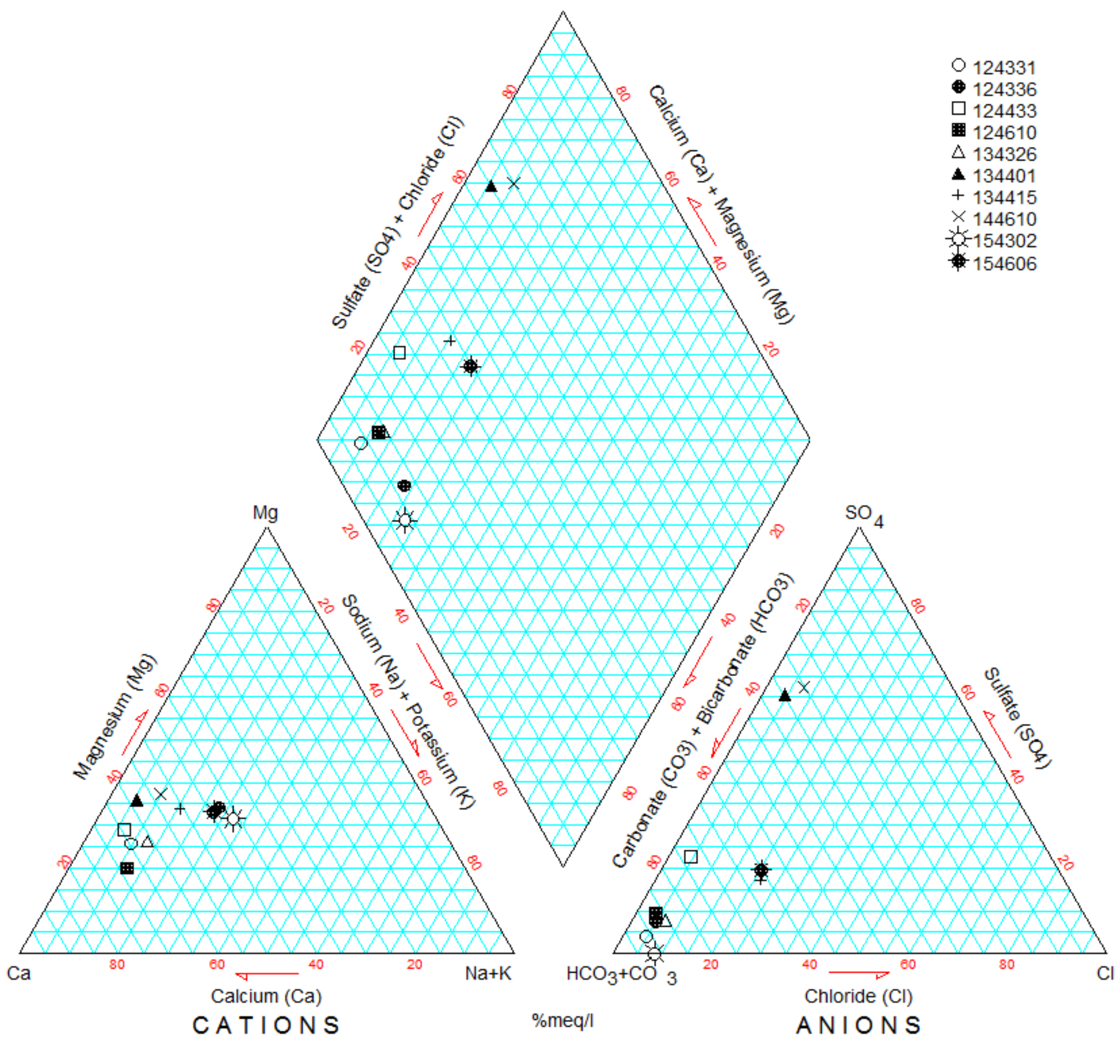


Figure 35. Piper diagram—PRO Ambient Regional Ground Water Monitoring Project.

With the exception of chloride and sulfate, most ionic constituents exhibited only minor variations between the 1976 and 2014 samples. In the 2014 samples, chloride ranged from 7.52 to 69.5 with a median value of 13.8 mg/L. In 1976, these wells had chloride concentrations ranging from 3.1 to 63 with a median value of 8 mg/L. Chloride concentration increases were over 300% at 134326 and 154302 and over 100% at 124433 and 154606. Sulfate concentration increased over 150% at 134326 and over 50% at 134415 and 154606. Welhan and Poulson (2009) have related elevated sulfate and chloride concentrations to various sources including septic discharge, feedlot runoff, inorganic fertilizers, and evaporation from shallow ground water.

Arsenic Results

Arsenic was detected in 5 of the 10 sites; concentrations ranged from 2.3 μg/L to 32.4 μg/L, with 4 of the 5 sites below the MCL for arsenic of 10 μg/L. Well 154302 had an arsenic concentration of 32.4 μg/L, which is more than three times the MCL (Table 27). This concentration was consistent with four previous samples dating back to 1993 (IDWR 2015), ranging from 29.4 to 38 μg/L, and is likely the result of a natural source of the element. Arsenic at other sites ranged from <2.0 μg/L to 5.4 μg/L.

Fluoride Results

Fluoride concentrations were all well below the MCL of 4 mg/L; the results ranged from <0.20 mg/L to 0.705 mg/L (Well 134415).

Bacteria Results

Total coliform bacteria was present in 1 of the 10 sites sampled (Well 124336 at 2.0 MPN/100 mL). None of the sites tested positive for *E. coli* (Table 27).

Nitrate Results

Nitrate concentrations in the sampled wells ranged from <0.01 mg/L (154302) to 6.2 mg/L (Well 134415). Only three wells had concentrations of 2.0 mg/L or greater and one-half of the sampled wells showed a decrease in nitrate concentration from the 1976 result.

Figure 36 shows an apparent inverse relationship between the Na:Cl ratio and nitrate concentration. With regard to this relationship, Seiler (1996) cited data from Lemmon Valley, Nevada, indicating that elevated nitrate concentrations were typically associated with a Na-to-Cl ratio less than 2:1. That finding seems to hold for this data set and will be further examined as additional data are collected.

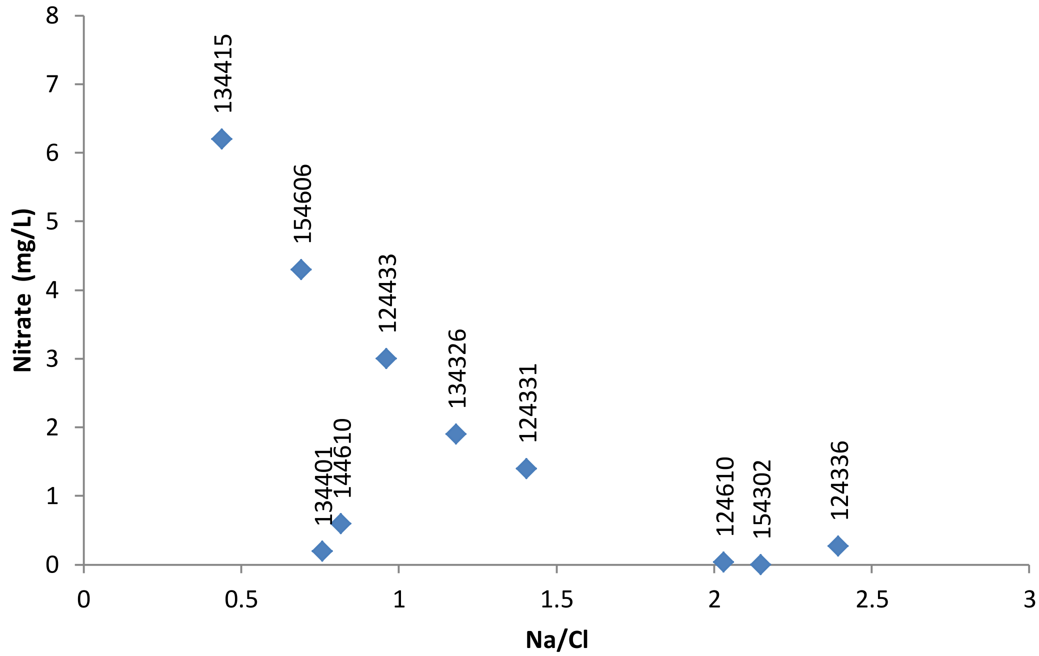


Figure 36. Na:Cl ratio versus nitrate concentration—PRO Ambient Regional Ground Water Monitoring Project.

Nitrogen Isotope Results

$\delta^{15}N$ ratios were obtained for the eight samples with sufficient nitrate concentrations. These values ranged from 5.42‰ to 25.26‰ (Table 27). Typical $\delta^{15}N$ values for common nitrate sources are listed in Table 4. The apparent source of nitrate is either organic nitrogen in the soil or a mixture of fertilizers and waste for 7 of the 8 sites. The exception was well 154606 (2438), which had the elevated $\delta^{15}N$ ratio of 25.26‰. With a corresponding $\delta^{18}O$ value of 6.38‰, the sample from Well 154606 appears to fall into the waste category. The elevated $\delta^{15}N$ value of 25.26‰, combined with the nitrate concentration of 4.3 mg/L, suggests potential denitrification of a waste source. The location of the well, which is near a corral, supports the waste source hypothesis.

2.5.1.3 Conclusions

The objectives of this project are to characterize current ground water conditions, identify areas and possible sources of degraded ground water quality, and evaluate changes in water quality over time. The data collected also provides a reference for future sampling. The data set presented here is the first of a 5-year effort to resample the regional monitoring network established by Seitz and Norvitch (1979). As such, a broader and more complete analysis will be reserved until data collection is complete.

The data set compiled from the 2014 sampling suggests the following:

- Changes in ground water chemistry since the 1976 sampling have been greatest in chloride and sulfate ion concentrations. Primary drinking water standards were exceeded only at one site, 154302, for arsenic (32.4 µg/L).

- Calcium and bicarbonate are dominant cations and anions in most of the sampled wells. Sulfate and chloride are significant anionic components in several wells.
- Nitrate concentrations decreased in one-half of the samples from 1976 concentrations and, in general, changes were small.
- Nitrate levels appear to be inversely related to the ratio of Na to Cl.
- Isotopic ratios suggest that the source of nitrate in most of the sampled wells is organic nitrogen in the soil or a mixture of fertilizers and waste. Denitrification may have altered the isotopic composition of another sample, making determination of nitrate source unclear.

2.5.1.4 Recommendations

The well owner with an arsenic concentration above EPA's MCL was advised of the testing results and given more information concerning arsenic in drinking water. Property owners with private domestic drinking water wells should sample and analyze their well water for bacteria and nitrate on an annual basis.

Additional recommendations are listed below:

- The 5-year data collection effort should be continued to support the goals of the project.
- Further examination of the apparent relationship of nitrate concentration to Na:Cl should be undertaken.
- Steps should be taken to encouraged homeowners to regularly maintain their septic systems and well heads.

2.6 Twin Falls Region

One ground water quality monitoring project was conducted in the Twin Falls region in 2014 using public funds.

2.6.1 Hollister Ground Water Monitoring Project

2.6.1.1 Purpose and Background

The purpose of this project was to evaluate ground water quality in an area east and southeast of the City of Hollister, Twin Falls County, partly in response to local public concerns that centered on the application of byproducts high in organic nitrogen from a local yogurt producer on approximately 900 acres of farmland southeast of Hollister in 2013 (Figure 37). The project area is also on the border of the Twin Falls NPA, where more information on current nitrate levels and sources of nitrate is needed. Investigation of the area could potentially identify the source and extent of nitrate contamination and provide useful information to residents regarding potential health effects.

Land in the area is used for irrigated agriculture, dairies, rangeland, and some residential, with a small recreational zone for the Nat Soo Pah hot springs facility about 3 miles east of Hollister. Ground water flows from the hills east of Hollister in a northwesterly direction, then as the terrain flattens out, flows due north toward the Snake River.

Basalt flows in the Twin Falls region are associated with the Pleistocene Glenns Ferry Formation, while underlying (older) flows are associated with the Miocene Banbury Basalt. Cumulative thickness of these units in the Hollister area is likely on the order of 1,000 feet (Malde et al. 1963; Whitehead 1986 cited in DEQ 2013d), consisting primarily of Banbury Basalt (Young and Newton 1989 cited in DEQ 2013d). Underlying the Banbury Basalt is a group of largely silicic rocks called the Idavada Volcanics, which consist primarily of welded ash flows. Water within this group is often geothermal (Malde et al. 1963; Malde and Powers 1972 cited in DEQ 2013d). The aquifer as a whole is considered unconfined, but the layered nature of basalt flows could result in a confined (or semi-confined) response locally. Vertical ground water movement is dependent on the degree of fracturing and faulting through the basalt units and interbeds but is likely (DEQ 2013d). Water level contours based on water level elevations from IDWR indicate ground water is flowing north within the study area (Figure 37).

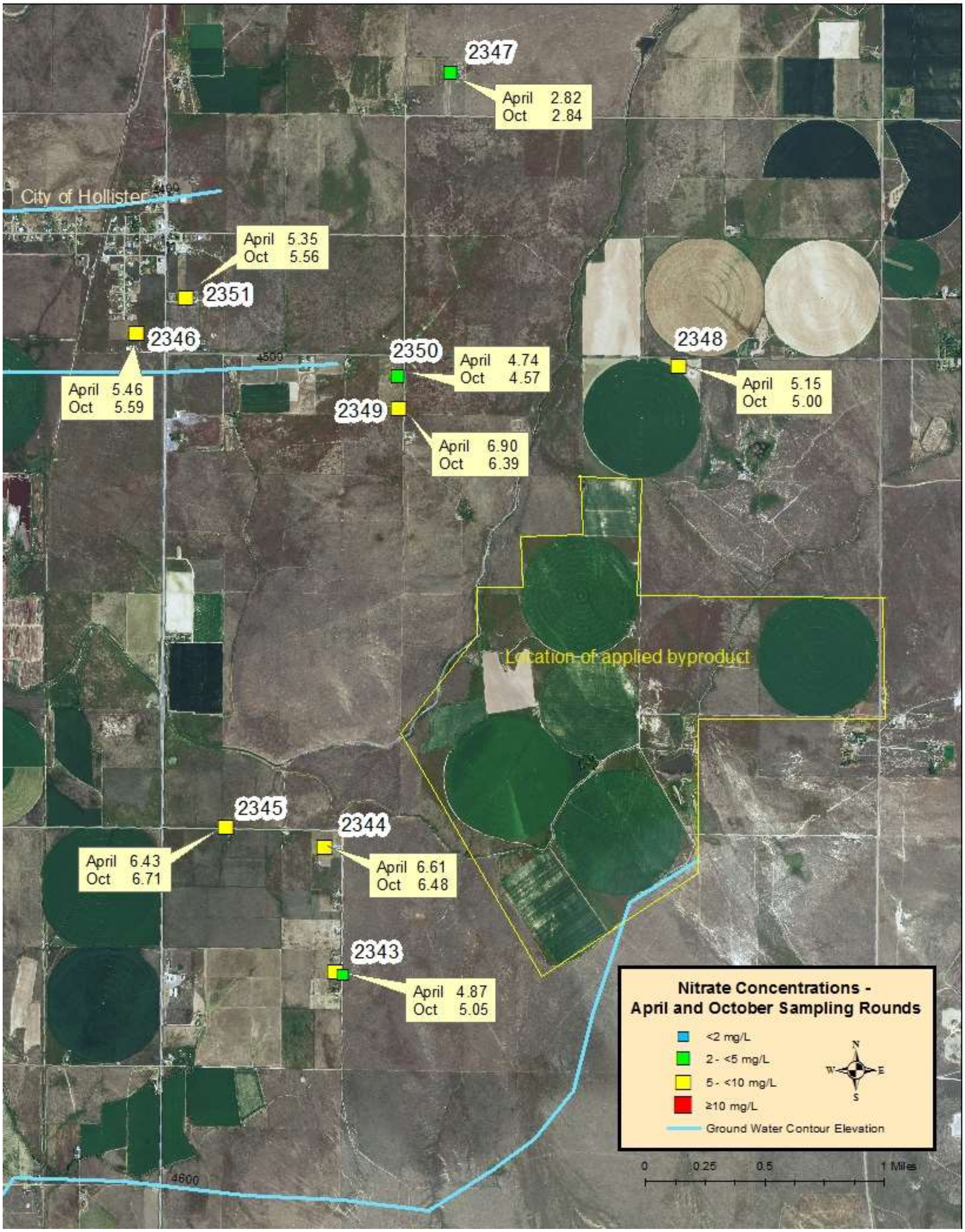


Figure 37. Location of wells sampled, distribution of nitrate concentrations and location of nearby farm where yogurt byproduct waste was applied—Hollister Ground Water Monitoring Project.

2.6.1.2 Methods and Results

Nine domestic wells were sampled during two sampling rounds in April and October 2014 (Figure 37). All sampling was conducted in accordance with the TFRO ground water follow-up monitoring project QAPP (DEQ 2013b) and the TFRO Hollister ground water monitoring project FSP (DEQ 2014h). Wells were selected based on general proximity up- and downgradient from the property where yogurt byproduct was applied as a soil amendment. Additional well selection criteria to minimize poor well construction factors included an available well driller report, a completed depth less than 300 feet bgs, and a construction date after 1987. Driller's reports were available for eight of nine wells sampled; a driller's report for one well (Site ID 2348) was not available and well depth is unknown.

Water quality field parameters (pH, temperature, specific conductivity, and dissolved oxygen) were measured at each site prior to sample collection to ensure adequate purging of the well for a representative sample of the local aquifer (Table 28).

For the April sampling round, samples were collected for calcium, magnesium, sodium, potassium, chloride, fluoride, sulfate, total alkalinity, nitrite plus nitrate, total Kjeldahl nitrogen, ammonia, arsenic, total coliform, and *E. coli* bacteria and submitted to Magic Valley Labs in Twin Falls for analysis. For the October sampling round, arsenic analysis was dropped and bromide and boron were added, as these constituents may help distinguish nitrate sources. After receiving nitrite plus nitrate results, samples for stable isotope analysis were submitted to Northern Arizona University-Colorado Plateau Stable Isotope Laboratory for stable isotopes of nitrogen and oxygen in nitrate ($\delta^{15}N_{nitrate}$, $\delta^{18}O_{nitrate}$) and to University of Arizona for stable isotopes of oxygen and hydrogen in water ($\delta^{18}O$ and $\delta^{2}H$) and for the stable isotope of total nitrogen in water ($\delta^{15}N$).

Table 28. Water quality field parameters—Hollister Ground Water Monitoring Project.

DEQ Site ID	Well Depth (feet)	Sample Date	Field Measurements			
			Water Temperature (°C)	Specific Conductivity (µS/cm)	Dissolved Oxygen (mg/L)	pH[a]
2343	240	April	13.73	932.4	7.39	7.87
		October	14.10	807	8.88	7.43
2344	245	April	16.59	1451	8.50	7.52
		October	17.03	1173	8.42	7.79
2345	202	April	15.64	1259	7.53	7.57
		October	16.16	1026	9.44	7.71
2346	250	April	13.91	1026	8.35	7.70
		October	13.58	925	8.31	7.84
2347	300	April	13.49	880	9.43	7.58
		October	13.11	799	12.81	7.73
2348	Unknown	April	10.37	926.7	8.59	7.56
		October	12.36	818	8.90	7.64
2349	255	April	11.13	1544	8.25	7.62
		October	13.35	1322	8.60	7.83
2350	85	April	13.01	1193	7.79	7.76
		October	12.91	905	8.63	7.80
2351	355	April	13.70	1056	7.89	7.68
		October	14.12	1036	8.63	7.72

[a] The NSDWR for pH is 6.5-8.5. NSDWR standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality.

Table 29 shows major ion and nutrient results, and Table 30 provides results of the major stable isotopes sampled.

Table 29. Major ion and nutrient results—Hollister Ground Water Monitoring Project.

DEQ Site ID	Sample Date	Major Ion, Inorganic, and Nutrient Concentrations													
		Calc-ium	Magne-sium	Sodium	Potassium	Chloride[a]	Fluoride[b]	Sulfate[a]	Bromide	Alkalinity (as $CaCO_3$)	Arsenic[b] (µg/L)	Boron	Nitrate + Nitrite/N[b]	TKN	Ammonia
		(mg/L) unless specified below constituent above													
Primary or Secondary Standard:		*NA*	*NA*	*NA*	*NA*	*250*	*4*	*250*	*NA*	*NA*	*10*	*NA*	*10*	*NA*	*NA*
2343	April	45	22	100	8.5	61.3	0.63	112	—	269	9.6	—	4.87	0.24	<0.05
	October	56	25	110	11	57.7	0.67	113	0.41	232	—	0.39	5.05	0.23	0.05
2344	April	87	45	120	15	168	0.48	*285*	—	218	3.4	—	6.61	0.24	<0.05
	October	100	47	120	20	164	0.49	*284*	1.29	206	—	0.29	6.48	0.31	<0.05
2345	April	80	34	110	12	110	0.48	196	—	254	3.5	—	6.43	0.25	<0.05
	October	85	32	100	16	111	0.49	210	0.86	264	—	0.26	6.71	0.29	<0.05
2346	April	47	28	110	3.6	83	0.74	122	—	241	**12**	—	5.46	0.23	<0.05
	October	58	30	110	4.6	92.6	0.75	147	0.54	256	—	0.27	5.59	0.27	<0.05
2347	April	52	19	100	24	80.2	1.72	138	—	216	<3.0	—	2.82	0.11	<0.05
	October	55	17	94	32	77.2	1.73	139	0.54	220	—	0.23	2.84	0.19	<0.05
2348	April	40	18	110	24	45.4	1.67	130	—	254	6.5	—	5.15	0.14	<0.05
	October	57	20	110	23	40.4	1.63	118	0.31	242	—	0.38	5.00	0.13	<0.05
2349	April	76	29	190	20	175	1.43	*299*	—	194	**15**	—	6.90	0.28	<0.05
	October	100	33	190	19	162	1.30	*280*	1.10	190	—	0.38	6.39	0.25	<0.05
2350	April	56	20	140	21	121	1.35	208	—	183	5.1	—	4.74	0.22	<0.05
	October	78	23	150	21	111	1.34	195	0.80	186	—	0.33	4.57	0.18	<0.05
2351	April	48	30	100	7.2	93.1	0.95	162	—	217	**11**	—	5.35	0.26	<0.05
	October	78	41	120	7.2	91.4	0.61	182	0.90	234	—	0.34	5.56	0.22	<0.05

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation (NPDWR) standard, expressed as a maximum contaminant level (MCL), was exceeded. Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation (NSDWR) standard was exceeded. These standards are recommended limits for public water systems but can be applied to private wells to evaluate water quality. (—) = data are unavailable or were not analyzed.

[a] Contaminant with a National Secondary Drinking Water Regulation standard.

[b] Contaminant with a National Primary Drinking Water Regulation standard.

Table 30. Major stable isotope results—Hollister Ground Water Monitoring Project.

DEQ Site ID	Sample Date	Major Isotopes				
		$\delta^{18}O$	$\delta^{2}H$	$\delta^{15}N$	$\delta^{15}N_{nitrate}$	$\delta^{18}O_{nitrate}$
		(‰)				
2343	April	-14.9	-118	5.3	4.60	-5.35
	October	-14.6	-117	5.4	5.08	-4.44
2344	April	-15.4	-122	6.9	5.73	-6.15
	October	-15.3	-121	6.9	6.77	-4.30
2345	April	-15.1	-120	5.8	5.00	-5.89
	October	-15.1	-120	10.2	5.71	-4.24
2346	April	-14.7	-118	4.8	4.62	-5.35
	October	-14.6	-117	6.1	5.33	-4.28
2347	April	-16.1	-126	6.3	6.16	-5.37
	October	-15.9	-125	6.3	6.21	-4.83
2348	April	-15.8	-124	3.7	4.10	-6.00
	October	-15.7	-123	4.7	4.41	-5.55
2349	April	-15.7	-124	8.4	8.88	-3.82
	October	-15.8	-124	11.5	8.73	-3.85
2350	April	-15.7	-124	6.9	7.11	-4.04
	October	-15.5	-123	7.7	7.23	-3.48
2351	April	-14.6	-118	5.9	5.97	-5.15
	October	-14.5	-117	7.8	7.27	-5.74

Notes: Stable isotope analytical results are presented as delta values (δ) reported as parts per thousand (identified as per mil or ‰) compared to a standard. For $\delta^{15}N$ and $\delta^{15}N_{nitrate}$, delta values represent $^{15}N/^{14}N$ of the sample compared to $^{15}N/^{14}N$ for nitrogen in air, reported as $\delta^{15}N_{air}$. Standards for $\delta^{18}O$, $\delta^{18}O_{nitrate}$, and $\delta^{2}H$ are Vienna Standard Mean Ocean Water (VSMOW).

General Ground Water Chemistry

Trilinear plotting shown in Figure 38 indicates some clustering in the right central portion of the quadrilateral or diamond shaped plot. While calcium-magnesium bicarbonate ground water might generally be expected in the Twin Falls hydrogeologic subarea (Neely 2001), this sampling indicates a calcium-sodium bicarbonate water with a sulfate and chloride influence. With an increase in chloride and sulfate, there is a corresponding decrease in bicarbonate. The sulfate secondary drinking water standard of 250 mg/L was exceeded in two wells. A sulfate component can suggest a sulfate-based commercial fertilizer influence, but with correspondingly higher than expected sodium and chloride levels in this case, it could also indicate an organic waste source (Suen 2008; Katz et al. 2011). There is a definite positive relationship between chloride and sulfate and between chloride and bromide concentrations (Figure 39 and Figure 40), which strengthens the connection to a possible organic waste source. However, the chloride to bromide mass ratios observed, which ranged from 102 to 147, fall below what Katz et al. (2011) for example described for a septic source. Neely (2001) also found slightly different water chemistry southwest of Twin Falls, with chloride and sulfate as dominant anions. The sites in that category had well depths greater than 260 feet. One difference is that most of the Hollister study sites were less than 260 feet.

There also seems to be a subtle spring to fall shift in the major cations, with more relative magnesium to calcium in the spring compared to the fall samples.

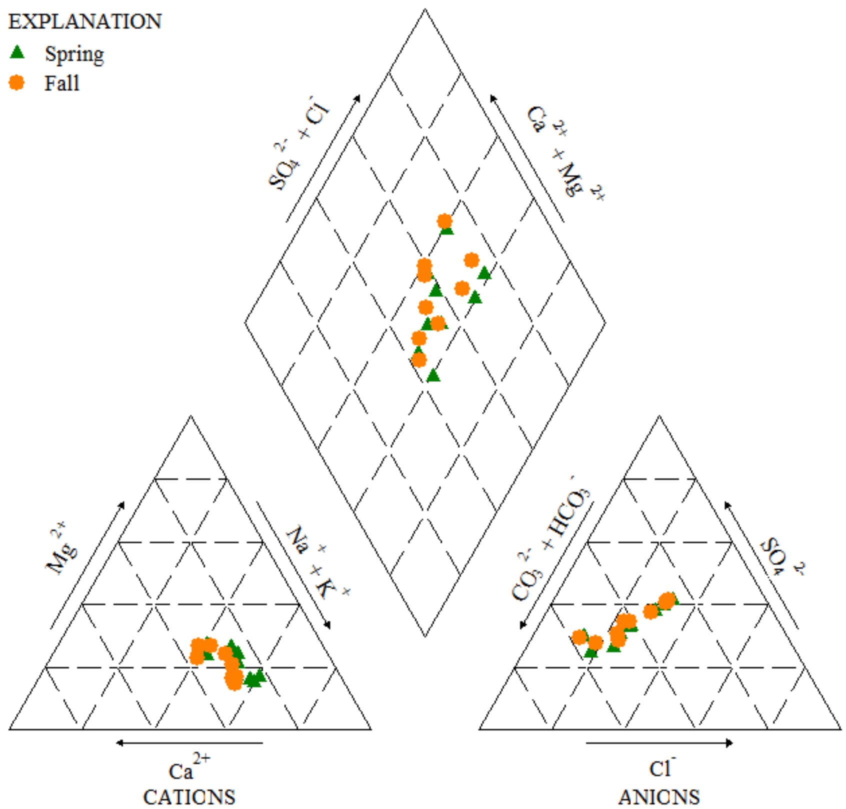


Figure 38. Trilinear diagram—Hollister Ground Water Monitoring Project.

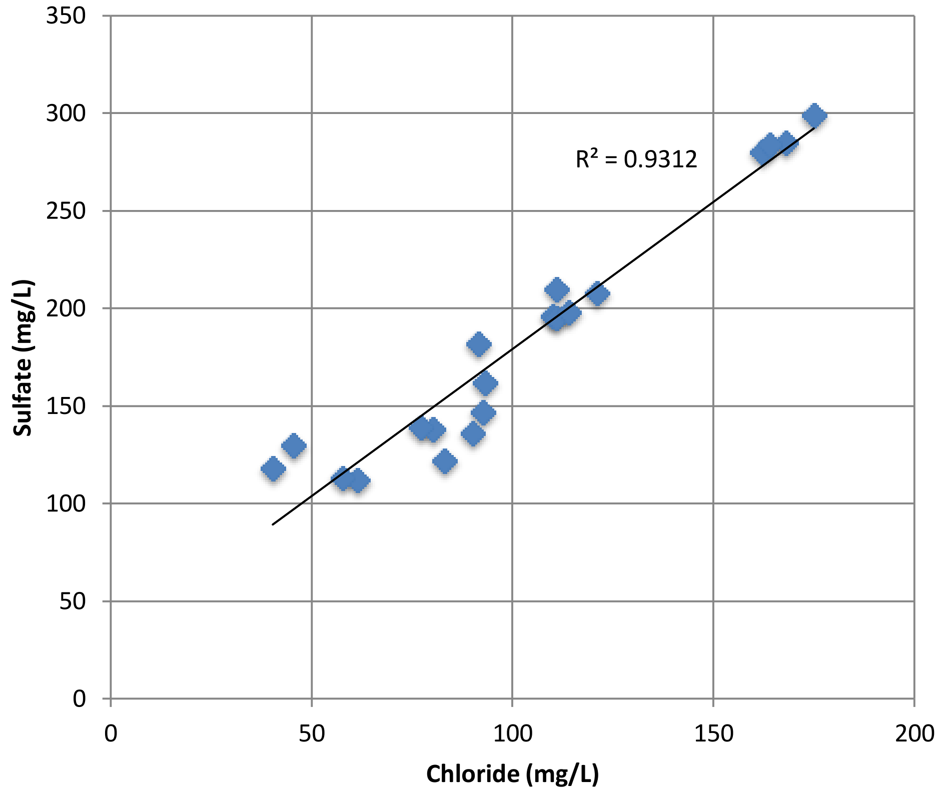


Figure 39. Chloride versus sulfate—Hollister Ground Water Monitoring Project.

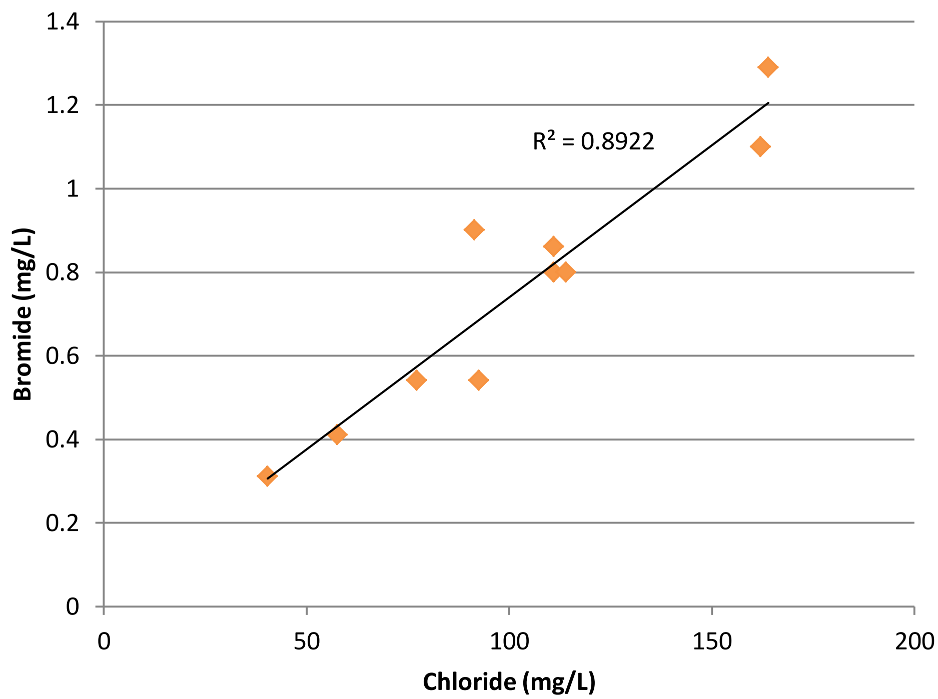


Figure 40. Chloride versus bromide—Hollister Ground Water Monitoring Project.

Arsenic Results

Arsenic samples were collected in the first round of sampling primarily as a service to the homeowners who allow their wells to be used for the study. Arsenic is a trace element and is known to occur at levels above the drinking water MCL of 10 μg/L in Twin Falls County ground water as a result of natural conditions. Arsenic levels ranged from <3.0 to 15 μg/L; 3 of the 9 wells (2346, 2349, 2351) had concentrations above the MCL of 10 μg/L.

Bacteria Results

Similar to arsenic, bacteria (total coliform and *E. coli*) samples were collected in the first round of sampling primarily as a service to the homeowners who allow their wells to be used for the study. None of the 9 wells tested positive for total coliform or *E. coli*.

Nitrate Sampling

The 9 wells sampled had nitrate values ranging from 2.82 mg/L to 6.90 mg/L, with a median value of 5.4 mg/L. None of the wells exceeded EPA's nitrate MCL of 10 mg/L. Spatial distribution of nitrate results is shown in Figure 37.

Isotope Sampling

Stable isotopes of oxygen and hydrogen help characterize the source of recharge to the aquifer. Results for the Hollister samples plot along the Eastern Snake River Plain (ESRP) water line (Figure 41) and along the upper end of the line indicating that the water contributing recharge was modified by evaporation prior to infiltrating to the aquifer. Therefore, a majority of the recharge likely occurs during the summer when irrigation water becomes a significant source of recharge to the aquifer. The ESRP water line was generated from a long-term USGS study of the Eastern Snake River Plain aquifer (Wood and Lowe 2002).

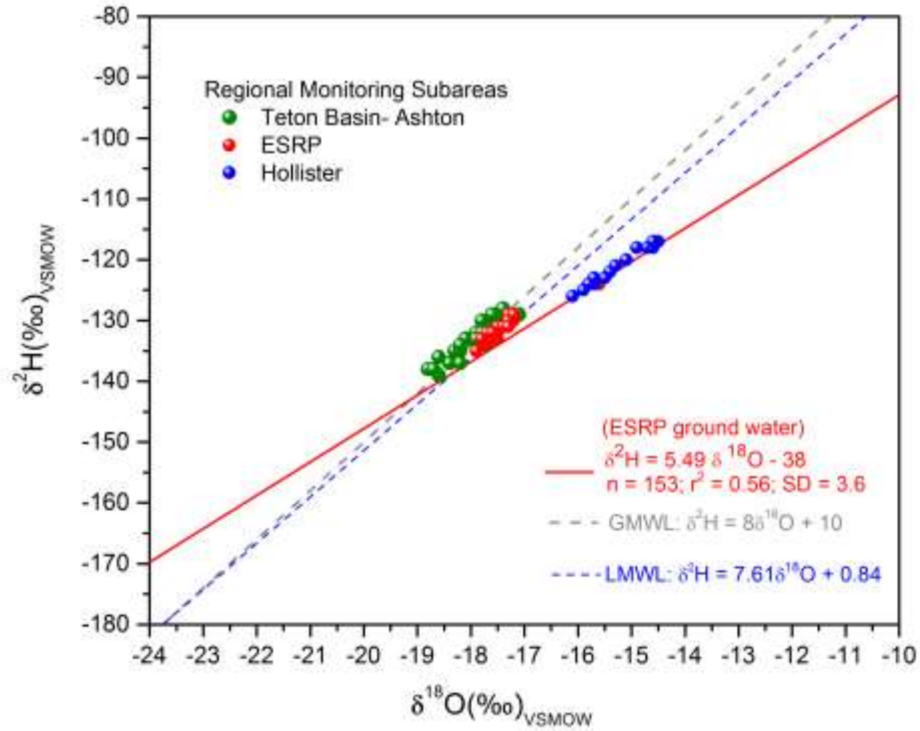


Figure 41. $\delta^{18}O$ versus $\delta^{2}H$ Hollister results compared to ESRP results and meteoric water levels—Hollister Ground Water Monitoring Project.

Nitrogen isotope ratio analysis was performed on all samples. The $\delta^{15}N$ values ranged from 3.7‰ to 11.5‰, with ratios tending to increase slightly in the fall samples for most of the sites (Table 30). The isotope ratios—along with a combination of other analytes such as sulfate, chloride, sodium, bromide, and boron—can be useful in identifying potential sources of nitrate. Typical $\delta^{15}N$ ratios for various nitrogen sources according to Seiler (1996) are shown in Table 4.

October samples from two sites (2345, 2349) had a $\delta^{15}N$ signature typical of organic wastes (Table 29). These sites may be influenced by the yogurt byproduct waste applied to the south and east but may also be influenced by their onsite septic system, though setbacks are within health district regulatory guidelines. One site (2348) had a ratio of 3.7‰, which is characteristic of a commercial fertilizer isotopic signature. This particular well borders and is downgradient of an agricultural field. Figure 42 shows that the Hollister nitrogen and oxygen isotopes of nitrate primarily fall within the soil nitrogen and mixed source zone. The one data point tending toward the manure and septic waste zone is from site 2349. The two lowest reported $\delta^{15}N_{nitrate}$ ratios (4.10‰ in April and 4.41‰ in October) are from site 2348, which borders an agricultural field.

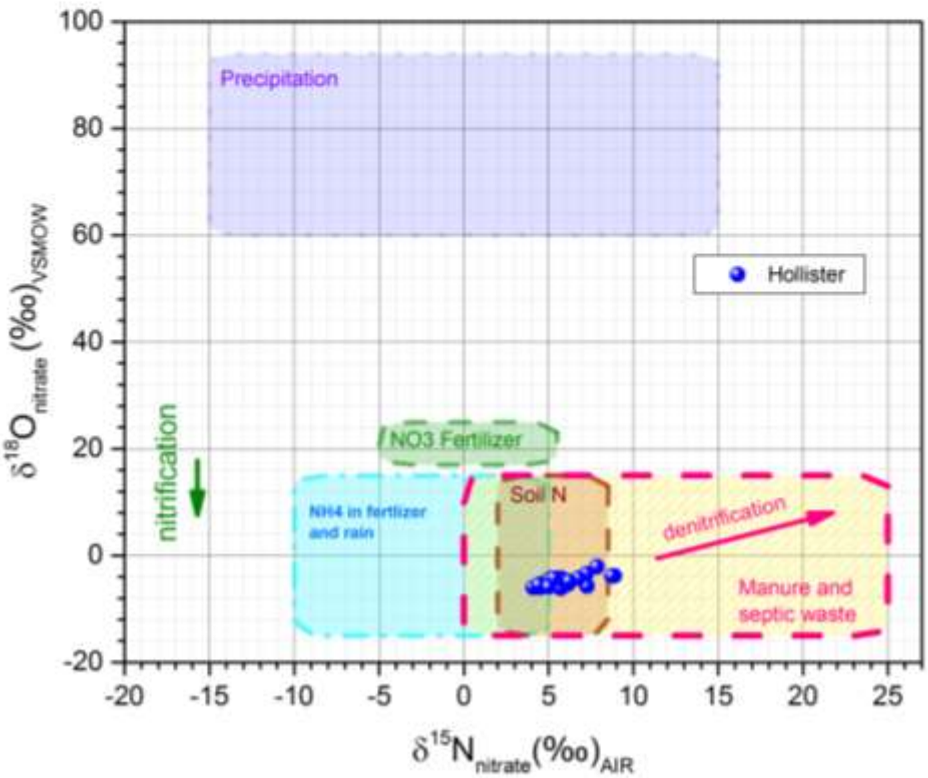


Figure 42. $\delta^{15}N_{nitrate}$ versus $\delta^{18}O_{nitrate}$—Hollister Ground Water Monitoring Project, 2014. Ranges for typical nitrate sources are from Kendall 2007.

2.6.1.3 Conclusions

None of the nine wells sampled for this project exceeded EPA's MCL for nitrate in either April or October. All wells with the exception of the most northerly and downgradient site (2347) approach or exceed 5 mg/L, which indicates an impact to water quality from an anthropogenic source or activity.

The nitrogen isotope ratios along with some of the major ions provide some clues to the sources of these nitrate levels. The data seem to fit the model for typical nitrate source ranges with an organic waste component that may be related to the yogurt byproduct field applications or onsite septic system drainage.

Manure from the local dairy applied as fertilizer to fields in the area cannot be discounted as a nitrate source either, but information on location or application timing and rates is lacking for these activities. Most of the nitrogen isotope data exhibit a mixed source or soil nitrogen signature. One site on the border of an agricultural field exhibited a nitrogen isotope ratio more characteristic of a synthetic fertilizer signature. While there are many limitations with a small dataset, it is useful in showing local influences.

2.6.1.4 Recommendations

The well owners with arsenic concentrations above EPA's MCL were advised not to drink or cook with the well water until the water was treated. Property owners with private domestic drinking water wells were also advised to analyze their well water for bacteria and nitrate on an annual basis.

Additional ground water quality monitoring should be conducted throughout the Twin Falls NPA to more fully document any nitrate trends over time and to better understand the sources of the nitrate contamination in the region.

Future projects may benefit from additional data on local crop mixes recorded and land application rates and timing of organic or inorganic types of fertilizer, if possible. Continuing to monitor and use a combination of chemical analyses, including nitrogen and oxygen isotopes, chloride, sulfate, bromide, sodium, and boron will provide the best chance for identifying and understanding the sources of nitrate in the region.

3 DEQ Cooperative Projects

This section presents data from special ground water quality monitoring and investigation projects that were conducted jointly by DEQ and other state agencies in calendar year 2014.

3.1 DEQ–ISDA Ground Water Monitoring Project

3.1.1 Purpose

The ISDA Ground Water Program has developed a ground water monitoring network across the state of Idaho to assess the impacts of pesticide use on ground water quality. DEQ partnered with ISDA and paid for analysis of common ions, nitrate, metals, and $\delta^{15}N$ to help assess ground water quality across the state. The ground water samples were collected by ISDA staff in conjunction with pesticide sampling events, while DEQ paid for the analysis. The data will help identify areas of concern and potential health threats associated with degraded ground water quality. Additionally, the information will be used to augment data from PWSs, the IDWR Statewide Ambient Ground Water Quality Monitoring Network, and local-scale monitoring projects to be used in the NPA ranking process.

3.1.2 Methods and Results

ISDA collected 209 samples from domestic wells across the state following its EPA-approved QAPP. Samples were submitted to the UIASL in Moscow for analysis of nitrate. Samples collected in Owyhee County were also analyzed for ammonia due to the anaerobic nature of the aquifer in the area. Most samples with nitrate concentrations above 5 mg/L were sent to the University of Arizona for $\delta^{15}N$ analysis. The analytical results are shown in Appendix A.

Nitrate Results

Nitrate concentrations for this project ranged from nondetect (<0.050 mg/L) to 110 mg/L. Out of the 209 samples collected for nitrate analysis, 59 samples (28%) met or exceeded the EPA MCL of 10 mg/L for nitrate. In total, 169 samples (81%) were at or greater than 2 mg/L, indicating some type of non-naturally occurring nitrogen source; 2 mg/L is generally considered background level (DEQ 2014a).

Well locations and nitrate concentrations are shown in Table A1 and Figures A1–A12 in Appendix A.

Nitrogen Isotope Results

Nitrogen isotope ratio analysis was performed on 36 samples, all of which had nitrate concentrations at or greater than 5 mg/L. The $\delta^{15}N$ values ranged from 1.5‰ to 13.2‰ (Appendix A, Table A1). Samples from 8 wells had $\delta^{15}N$ values ranging from +1.5‰ to +3.7‰, indicating commercial fertilizer as the likely nitrate source; 23 samples had $\delta^{15}N$ values between 4.3‰ and 8.0‰, indicating organic nitrogen in soil or a mixed nitrogen source as the likely nitrate source; 5 wells had $\delta^{15}N$ values greater than 9‰, indicating an animal or human waste source as the likely nitrate source (Table 4).

3.1.3 Conclusions

The cooperative project between ISDA and DEQ resulted in the cost-effective collection of additional nitrate and nitrogen isotope data that helped assess ground water quality across the state. Out of the 209 samples collected for nitrate analysis, 59 samples (28%) met or exceeded the EPA MCL of 10 mg/L for nitrate. The nitrate results indicate the degradation of ground water in specific vulnerable aquifers. The nitrogen isotope ratios provide one line of evidence for the potential source(s) of nitrogen contributing to the nitrate concentrations in ground water. These data will be helpful in the next NPA delineation and ranking process conducted by DEQ and the Ground Water Monitoring Technical Committee.

3.1.4 Recommendations

This project is an example of a cooperative effort between state agencies in Idaho saving time and money by using existing ground water monitoring networks and sampling schedules. ISDA and DEQ should continue these cooperative efforts to increase program efficiency and protect ground water quality in the state of Idaho.

3.2 DEQ–IDWR Ground Water Monitoring Project

3.2.1 Purpose

The purpose of the DEQ–IDWR Ground Water Monitoring Project was to combine resources and work collaboratively to assess ground water quality by using the IDWR Statewide Ambient Ground Water Quality Monitoring Network (SMN). IDWR conducts yearly monitoring of its network for various water quality constituents, and DEQ allocated funding for the collection of additional parameters to further identify areas of concern and gain additional understanding of background levels of constituents.

In 2014, DEQ partnered with IDWR to expand their immunoassay testing for various pharmaceutical and personal care products (PPCP) by adding a sulfamethoxazole test to their sample collection process. IDWR conducted the PPCP testing throughout the state at the IDWR SMN wells.

DEQ also requested that IDWR collect methane samples from select IDWR SMN wells in southwest Idaho. The data obtained from these sampling efforts will help identify areas of concern and potential health threats associated with degraded ground water quality.

3.2.2 Methods and Results

Sulfamethoxazole

IDWR collected 233 samples from the IDWR SMN wells across the state for various PPCP analysis using enzyme-linked immune sorbent assay (ELISA) kits. Since only sulfamethoxazole was paid for by DEQ, the sulfamethoxazole results are the only PPCP results included in this report. The kits were analyzed by IBL. The positive sulfamethoxazole results are found in Table 31, and all results are included in Appendix B, Table B1, and Figure 43.

Of the 233 samples collected for sulfamethoxazole analysis, 2 had positive detections (0.8%). The two positive detections of 0.41 mg/L and 0.46 mg/L were found in Elmore and Minidoka counties, respectively (Figure 43). Sulfamethoxazole is an antibiotic primarily used in humans, horses, cats, and dogs. It is also often used by veterinarians to treat calves (Fuselier 2012). The presence of this drug indicates impact from human or animal waste sources. Evaluation of the land use and the complete suite of water quality data is needed to confirm the source of the drug.

**Table 31. Sulfamethoxazole results (positive detections only)—
IDWR-DEQ Joint Sampling Project.**

IDWR Site ID	Date Sampled	Sulfamethoxazole Concentration (mg/L)
05S 09E 27DBB1	08/05/2014	0.41
10S 23E 09CBCB1	08/29/2014	0.46

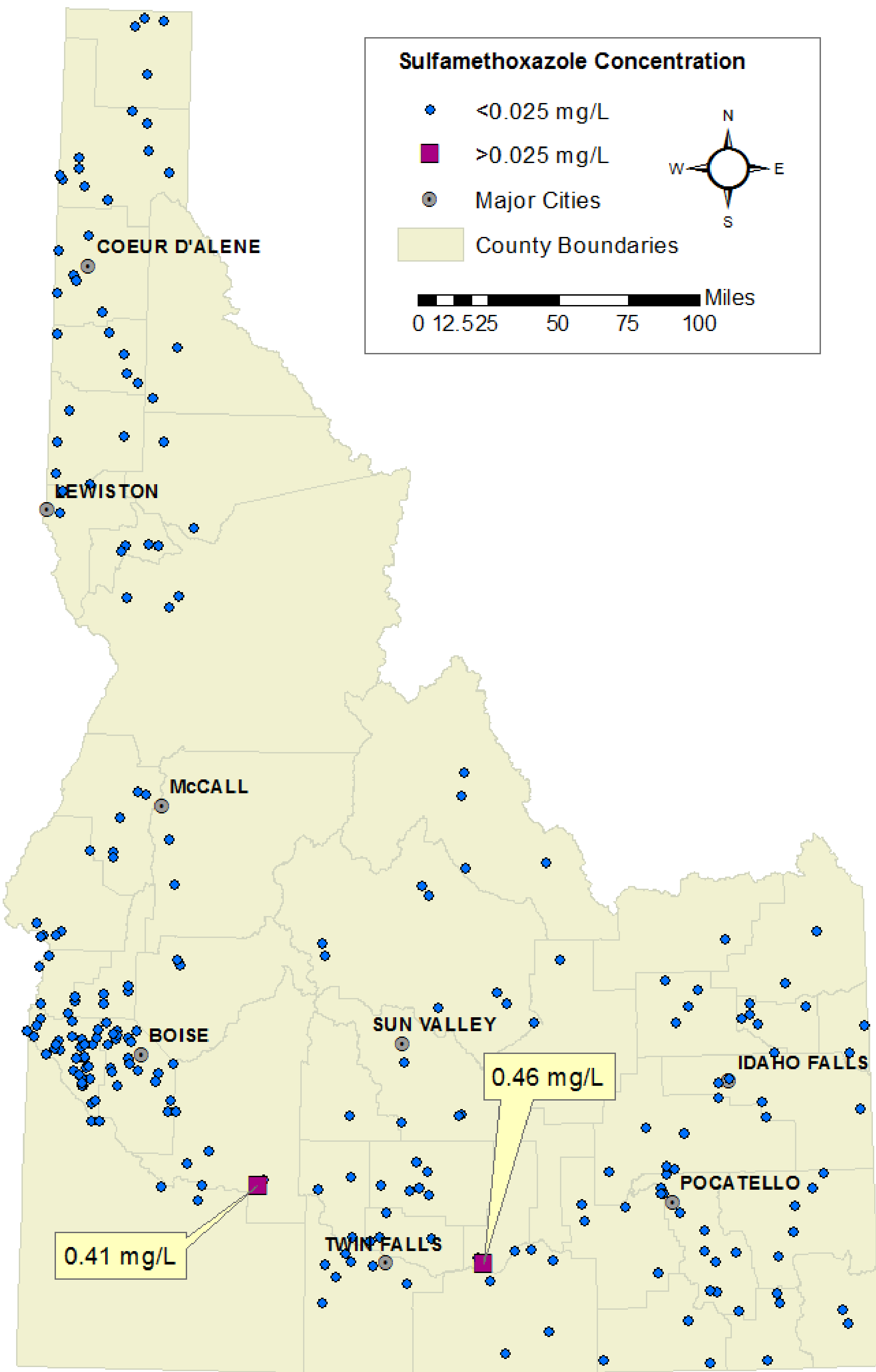


Figure 43. Sulfamethoxazole concentrations—IDWR-DEQ joint sampling project.

Methane

Well selection criteria for methane sampling was based on wells scheduled for monitoring under IDWR's SMN plan as well as locations within a county with potential for oil and natural gas development. A total of 43 wells were sampled for methane in August 2014. Samples were collected by IDWR and were submitted to the IBL; IBL subcontracted the analysis to Accutest Laboratories. The analytical results for all 43 wells are shown in Table 32 and Figure 44.

Methane samples were collected from 43 IDWR SMN wells located in southwest Idaho in August 2014; 17 wells had positive detections (Table 32; Figure 44). The methane results ranged from below the laboratory detection limit (<0.00040 mg/L) to 7.8 mg/L. Methane (CH_4) is a naturally occurring hydrocarbon that is odorless, colorless, and tasteless. It is the primary constituent of natural gas and can be flammable or explosive in high concentrations. Currently, neither a federal or state drinking water quality standard establishes a limit for dissolved methane in ground water. However, since the primary health risk from dissolved methane is an explosion risk, the US Department of Interior Office of Surface Mining recommends that wells with concentrations greater than 28 mg/L be vented or remedied using alternative methods. Wells with concentrations greater than 10 mg/L but less than 28 mg/L may warrant removing potential ignition sources from the immediate area (Eltschlager et al. 2001).

Table 32. Methane results—IDWR-DEQ joint sampling project.

IDWR Site ID	Date Sampled	Methane Concentration (mg/L)
432654116375801	08/11/2014	<0.00040
432917116373901	08/11/2014	<0.00040
433304116350102	08/11/2014	<0.00040
432928116340601	08/11/2014	0.002
433022116385401	08/11/2014	0.00086
433746116473101	08/11/2014	<0.00040
433948116333201	08/11/2014	<0.00040
433627116532701	08/07/2014	<0.00040
434151116315501	08/07/2014	0.0021
433935116364701	08/07/2014	<0.00040
433302116294102	08/07/2014	<0.00040
435543116295501	08/07/2014	<0.00040
435248116290001	08/07/2014	0.157
425222115470401	08/04/2014	0.00099
431616116330301	08/04/2014	<0.00040
441238116483301	08/11/2014	<0.00040
441326116510701	08/11/2014	7.8
441304116561401	08/11/2014	0.00049 J
432147116333601	08/12/2014	<0.00040
433140116413601	08/12/2014	<0.00040
433602116363801	08/12/2014	<0.00040
433521116402001	08/18/2014	<0.00040
434128116383601	08/13/2014	<0.00040
434207116422801	08/13/2014	0.0214
434059116480401	08/18/2014	0.0455
434459116575001	08/12/2014	<0.00040
434733116561501	08/12/2014	2.71
434436116313601	08/18/2014	<0.00040
433843116384301	08/18/2014	0.0029
434139116583801	08/13/2014	<0.00040
435821116192501	08/13/2014	0.00054 J
425617116024401	08/12/2014	0.0029
431620116294501	08/12/2014	0.0051
441706116593501	08/13/2014	<0.00040
443946116373301	08/13/2014	0.00057 J
433929116491502	08/20/2014	<0.00040
435630116190901	08/19/2014	<0.00040
435304116413002	08/19/2014	<0.00040
435433116420501	08/19/2014	<0.00040
440312116574501	08/19/2014	0.0584
434920116442701	08/19/2014	<0.00040
440649116532701	08/19/2014	<0.00040
441233116574201	08/19/2014	0.0011

Note: J indicates an estimated value.

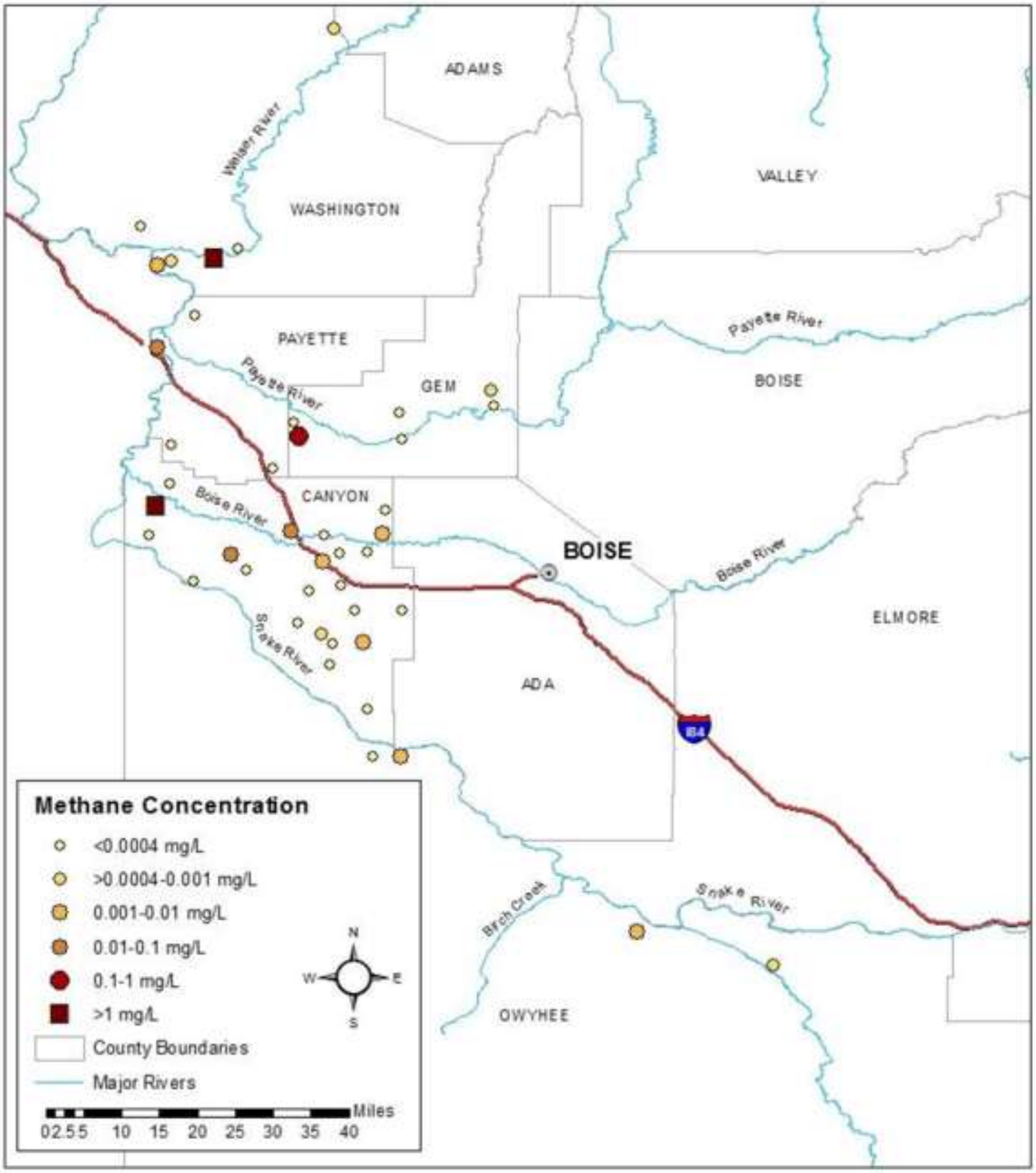


Figure 44. Methane concentrations—IDWR-DEQ Joint sampling project.

3.2.3 Conclusions

The cooperative project between IDWR and DEQ resulted in the cost-effective collection of sulfamethoxazole and methane data that helped assess ground water quality across the state.

Of the 233 wells sampled for sulfamethoxazole, 2 had positive detections. Although the concentrations were low, the sulfamethoxazole detections indicate the possible impact to ground water from an animal or human waste source.

A total of 17 of the 43 IDWR SMN wells sampled for methane had positive detections; two of the 17 wells had concentrations of at least 10% of the explosive risk level of 28 mg/L. The methane results confirm the presence of methane at low concentrations in portions of southwest Idaho. This data provides a baseline for methane and will be useful if areas near these wells are developed for natural gas production.

3.2.4 Recommendations

This project was a good example of a cooperative effort between state agencies in Idaho saving time and money by using existing ground water monitoring networks and sampling schedules. IDWR and DEQ should continue these cooperative efforts to increase program efficiency and protect ground water quality in the state of Idaho.

This page intentionally left blank for correct double-sided printing.

References

Alt, D.D. and D.W. Hyndman. 1995. *Northwest Exposures: A Geologic Story of the Northwest*. Missoula, MT: Mountain Press Publishing Company.

Baldwin, J., X. Dai, and M. McVay. 2008. *Camas Prairie Nitrate Priority Area Ground Water Monitoring Results.* Boise, ID: Idaho Department of Environmental Quality. Ground Water Quality Technical Report No. 29.

Bentz, B. 1998. *A Reconnaissance of Nitrite/Nitrate in Camas Prairie Ground Water, Volume I, Lewis and Idaho County*. Boise, ID: Idaho Department of Environmental Quality.

Castelin, P.M. 1976. "Reconnaissance of the Water Resources of the Clearwater Plateau, Nez Perce, Lewis and Northern Idaho Counties, Idaho." Boise, ID: Idaho Department of Water Resources. Water Information Bulletin No. 41.

Cecil, L.D., L.F. Hall, L. Benjamin, L.L. Knobel, and J.R. Green. 2005. "Comparison of Local Meteoric Water Lines for Southeastern Idaho, Western Wyoming, and South-Central Montana." *Journal of the Idaho Academy of Science* 41(2):13–28.

Craig, H. 1961. "Isotopic Variations in Meteoric Waters." *Science.* 133(3465):1702-1703.

Davis, S.N., D.O. Whittemore, and J. Fabryka-Martin. 1998. "Uses of Chloride/Bromide Ratios in Studies of Potable Water." *Ground Water* 36:338–50.

DEQ (Idaho Department of Environmental Quality). 2005. *Camas Prairie Ground Water Sampling Quality Assurance Project Plan.* Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2007. *Lindsay Creek Watershed Assessment and Total Maximum Daily Loads*. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2008. *Arsenic Occurrence in Ground Water in the Market Lake Area, Idaho*. Boise, ID: DEQ. Ground Water Quality Technical Report No. 34.

DEQ (Idaho Department of Environmental Quality). 2010. *Tammany Creek Watershed (HUC 17060103): TMDL Addendum*. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2011a. *Boise Regional Office Regional Ground Water Monitoring Network Design.* Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2011b. *Quality Assurance Project Plan and Sampling and Analysis Plan for General Ground Water Monitoring Activities*. Pocatello, ID: DEQ. TRIM record number 2014AGV495.

DEQ (Idaho Department of Environmental Quality). 2011d. *Quality Assurance Project Plan: Regional Nitrate Priority Area Ground Water Monitoring Activities, Idaho Falls Region*. Idaho Falls, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2012. *Quality Assurance Project Plan: Local Dairy Nitrate Exceedance Follow-up Ground Water Monitoring.* Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2013a. *Idaho Falls Regional Office Ambient Ground Water Monitoring Plan Development; Defining Subareas.* Idaho Falls, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2013b. *Quality Assurance Project Plan: Twin Falls Regional Office Ground Water Follow-up Monitoring Projects*. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2013c. *Regional Ground Water Monitoring Network Design, Idaho Falls Regional Office*. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2013d. *Source Water Delineation Modeling Report: City of Hollister, PWS #5420030 Well #3*. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2013e. *Summary Report for the Idaho Department of Environmental Quality Ground Water Quality Monitoring Projects—2010*. Boise, ID: DEQ. Ground Water Quality Technical Report No. 44.

DEQ (Idaho Department of Environmental Quality). 2013f. *Quality Assurance Project Plan: Ambient Ground Water Quality Investigation*. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2014a. *2014 Nitrate Priority Area Delineation and Ranking Process*. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2014b. Eastern Snake River Plain Subarea Regional Ground Water Monitoring Field Sample Plan. Idaho Falls, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2014c. *Emmett North Bench Nitrate Priority Area Regional Ground Water Monitoring Network Field Sampling Plan.* Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2014d. *Field Sampling Plan: Glenns Ferry Nitrate Priority Area Regional Ground Water Monitoring Network, Glenns Ferry, Idaho*. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2014e. *Field Sampling Plan: Mountain Home Nitrate Priority Area Regional Ground Water Monitoring Network, Mountain Home, Idaho*. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2014f. *Field Sampling Plan: Weiser Nitrate Priority Area Regional Ground Water Monitoring Network, Weiser, Idaho*. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2014g. *Field Sampling Plan: Ambient Regional Ground Water Monitoring Project*. Pocatello, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2014h. *Field Sampling Plan: Hollister Ground Water Monitoring Project*. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2014i. *Regional Generic Quality Assurance Project Plan: Regional Nitrate Priority Area Ground Water Monitoring Activities Boise Region.* Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2014j. *Sand Hollow Creek Complaint Follow-Up Ground Water Monitoring Project, Emmett, Idaho*. Boise, ID: DEQ.

DEQ (Idaho Department of Environmental Quality). 2014k. *Field Sampling Plan: Cottonwood Creek Ground Water Nitrate Investigation.* Lewiston, ID: DEQ.

DEQ and ISCC (Idaho Department of Environmental Quality and Idaho Soil Conservation Commission). 2008. *Camas Prairie Nitrate Priority Area Ground Water Quality Management Plan*. Boise, ID: DEQ.

Digital Atlas of Idaho. 2014. Available at *http://imnh.isu.edu/digitalatlas*. Accessed January 2014.

Eltschlager, K.K., J.W. Hawkins, W.C. Ehler, and F. Baldassare. 2001. *Technical Measures for the Investigation and Mitigation of Fugitive Methane Hazards in Areas of Coal Mining*. Pittsburgh, PA: US Department of the Interior, Office of Surface Mining Reclamation and Enforcement.

Fuselier, A.J. 2012. "Antibiotic Use In Food Animals." 2012 ISVMA Conference Proceedings – Large Animal Track.

Graham, W.G., and L.J. Campbell. 1981. "Groundwater Resources of Idaho." Boise, ID: Idaho Department of Water Resources.

Hagan, E. 2003. "Ground Water Quality Clearwater Plateau Hydrogeologic Subarea, 1990–2002." Idaho Department of Water Resources. Water Information Bulletin No. 50, Part 6.

Heaton, T.H.E. 1986. "Isotopic Studies of Nitrogen Pollution in the Hydrosphere and Atmosphere: A Review." *Chemical Geology* 59:87–102.

Idaho Code. 2014. "Department of Environmental Quality Primary Administrative Agency—Agency Responsibilities." Idaho Code §39-120.

IDAPA. 2014. "Idaho Rules for Public Drinking Water Systems." Idaho Administrative Code. IDAPA 58.01.08.

IDWR (Idaho Department of Water Resources). 1992. *Water Table Elevation Contours in the Snake River Plain Aquifer*. SDE Feature Class GIS file.

IDWR (Idaho Department of Water Resources). 2014. *Ground Water Quality – Environmental Data Management System.* Available at *maps.idwr.idaho.gov/map/edms.*

IDWR (Idaho Department of Water Resources). 2015. *Ground Water Quality – Environmental Data Management System.* Available at *maps.idwr.idaho.gov/map/edms*.

Katz, B.G., S.M. Eberts, and L.J. Kauffman. 2011. "Using Cl/Br Ratios and Other Indicators to Assess Potential Impacts on Groundwater Quality from Septic Systems: A Review and Examples from Principal Aquifers in the United States." *J Hydrol* 397:151–66.

Kendall, C. 1998. "Tracing Nitrogen Sources and Cycling in Catchments." In *Isotope Tracers in Catchment Hydrology*, C. Kendall and J.J. McDonnell, eds., 534–569. Amsterdam: Elsevier.

Kendall, C., E.M. Elliott, and S.D. Wankel. 2007. "Tracing Anthropogenic Inputs of Nitrogen to Ecosystems." In *Stable Isotopes in Ecology and Environmental Science*, R.H. Michener and K. Lajtha, eds., 375–449. Malden, MA: Blackwell Publishing.

Malde, H. E., H. A. Powers, and C. H. Marshall. 1963. *Reconnaissance Geologic Map of the West-Central Snake River Plain, Idaho*. United States Geological Survey Miscellaneous Geologic Investigations Map I-373.

Neely, K.W. 2001. *Ground Water Quality in the Twin Falls Hydrogeologic Subarea, 1991-2000*. IDWR. Water Information Bulletin No. 50, Part 4.

Newton, G.D. 1991. *Geohydrology of the Regional Aquifer System, Western Snake River Plain, Southwestern Idaho*. Washington D.C.: United States Government Printing Office, United States Geological Survey Professional Paper 1408-G.

Pastén-Zapata, E., R. Ledesma-Ruiz, T. Harter, A.I. Ramírez, and J. Mahlknecht. 2014. "Assessment of Sources and Fate of Nitrate in Shallow Groundwater of an Agricultural Area by Using a Multi-Tracer Approach." *Science of The Total Environment* 1(470-471):855–864.

Petrich, C.R. and S.M. Urban. 2004. *Characterization of Ground Water Flow in the Lower Boise River Basin*. Idaho Water Resources Research Institute Research Report IWRRI-2004-01.

Seiler, R.L. 1996. *Methods for Identifying Sources of Nitrogen Contamination of Ground Water in Valleys in Washoe County, Nevada*. United States Geological Survey Open-File Report 96-461.

Seitz, H.R. and R.F. Norvitch. 1979. *Ground-Water Quality in Bannock, Bear Lake, Caribou, and Part of Power Counties, Southeastern Idaho.* U.S. Geological Survey Water-Resources Investigations 79-14.

Shervais, J.W., G. Shroff, S.K. Vetter, S. Matthews, B.B. Hanan, and J.J. McGee. 2002. "Origin of the Western Snake River Plain: Implications from Stratigraphy, Faulting, and the Geochemistry of Basalts near Mountain Home, Idaho." In *Tectonic and Magmatic Evolution of the Snake River Plain Volcanic Province,* Bill Bonnichsen, C.M. White, and Michael McCurry, eds. Idaho Geological Survey Bulletin 30:343–361.

Stearns, H.T., L. Crandall, W.G. and Stewart. 1938. *Geology and Ground-Water Resources of the Snake River Plain in Southeastern Idaho.* US Geological Survey Water-Supply Paper 774.

Steinhorst, K. 2011. *Designing a Sampling Plan for Nitrate Priority Areas: Step 2*. May 12, 2011.

Stevens, G., D. Garwood, and D. Ralston. 2003. "Report of Geologic/Hydrogeologic Services City of Nez Perce Lewis County, Idaho." Idaho Water Resources Research Institute. Final report for Technical Assistance for Rural Ground Water Development with Idaho Program.

Suen, C.J. 2008. "Using Isotopic Ratios and Major Minerals Data to Identify the Sources of Ground Water and Ground Water Nitrate in Relation to Pesticide Residues." Sacramento, CA: California Environmental Protection Agency. CWI-GEOL-08-DPR001.

Welhan, J.A., and N. Poulson. 2009. *Sources of Nitrate Contamination in Ground Water of Pleasant Valley, Power County, Idaho.* Idaho Geological Survey Staff Report 09-7.

Whitehead, R. L. 1992. "Geohydrologic Framework of the Snake River Plain Regional Aquifer System: Idaho and Eastern Oregon." US Geological Survey Professional Paper 1408-B.

Wood, S.H., and D.M. Clemens. 2002. "Geologic and Tectonic History of the Western Snake River Plain, Idaho and Oregon." In *Tectonic and Magmatic Evolution of the Snake River Plain Volcanic Province,* B. Bonnichsen, C.M. White, and M. McCurry, eds. Idaho Geologic Survey Bulletin 30:69–103.

Wood, W.W. and W.H. Low. 1988. *Solute Geochemistry of the Snake River Plain Regional Aquifer System, Idaho and Oregon*. US Geological Survey Professional Paper 1408-D.

This page intentionally left blank for correct double-sided printing.

Appendix A. Idaho State Department of Agriculture (ISDA) 2014 data.

Table A1. Field parameters, nitrate, ammonia and $\delta^{15}N$ results—ISDA 2014 data.

ISDA Well ID	Sample Date	Temperature (°C)	pH	Specific Conductivity	TDS	Nitrate	Ammonia	$\delta^{15}N$ (‰)
5302001	5/6/2014	13.0	7.23	585	287	**16**	NA	NA
5302401	5/6/2014	13.4	6.78	716	352	**18**	NA	NA
5302701	5/6/2014	14.3	6.86	721	353	**30**	NA	NA
5303401	5/6/2014	13.4	7.16	934	458	**39**	NA	NA
5303701	5/6/2014	13.4	6.86	689	337	**28**	NA	NA
7600601	5/6/2014	13.1	6.78	791	386	**37**	NA	NA
2200301	5/7/2014	14.2	7.53	715	350	**11**	NA	NA
2201701	5/7/2014	17.7	7.55	371	182	2.5	NA	NA
2203001	5/7/2014	13.3	7.02	543	266	4.6	NA	NA
2203101	5/7/2014	13.5	7.19	781	383	6.4	NA	NA
2204701	5/7/2014	15.0	7.25	631	309	6.1	NA	NA
2205701	5/7/2014	14.4	7.52	552	270	6.1	NA	NA
2201801	5/8/2014	13.7	7.35	582	285	7.0	NA	NA
2202601	5/8/2014	13.6	7.87	192	94	1.8	NA	NA
2230101	5/8/2014	15.4	7.32	752	368	4.7	NA	NA
7702501	5/13/2014	14.6	7.5	1104	540	4.4	NA	NA
7703001	5/13/2014	14.4	7.28	866	424	4.2	NA	NA
7703201	5/13/2014	14.5	7.27	1070	524	3	NA	NA
7703501	5/13/2014	14.3	*8.59*	182	89	<0.050	NA	NA
7705301	5/13/2014	14.0	7.24	857	420	**12**	NA	NA
7705201	5/14/2014	15.1	6.98	856	419	5.0	NA	NA
3400501	5/14/2014	15.4	7.18	990	485	**12**	NA	NA
3400701	5/14/2014	15.4	7.35	747	366	0.65	NA	NA
3400801	5/14/2014	15.0	7.01	930	457	**11**	NA	NA
3401401	5/14/2014	14.3	7.44	685	336	6.4	NA	NA
3401501	5/14/2014	14.3	7.46	831	407	**11**	NA	NA
7100501	5/15/2014	13.9	7.28	794	389	**16**	NA	NA
7100601	5/15/2014	14.9	7.28	798	391	**13**	NA	NA
7100901	5/15/2014	14.0	7.06	1040	509	**16**	NA	NA
7102301	5/15/2014	13.6	7.23	608	298	5.9	NA	NA
7102501	5/15/2014	14.3	6.86	1228	601	**15**	NA	NA
7103801	5/15/2014	16.3	7.08	865	424	**11**	NA	NA
7104001	5/15/2014	15.4	7.28	892	438	**20**	NA	NA
7103301	5/19/2014	15.9	7.2	698	342	5.1	NA	NA
7104101	5/19/2014	13.6	6.96	1422	696	**27**	NA	NA

ISDA Well ID	Sample Date	Temperature (°C)	pH	Specific Conductivity	TDS	Nitrate	Ammonia	$\delta^{15}N$ (‰)
7104201	5/19/2014	15.0	6.95	782	383	**16**	NA	NA
7104801	5/19/2014	13.7	7.42	818	401	**12**	NA	NA
7107001	5/19/2014	13.6	7.25	1079	529	**21**	NA	NA
7107101	5/19/2014	13.9	7.12	587	288	2.3	NA	NA
7101201	5/20/2014	13.0	7.4	929	455	**12**	NA	NA
7102101	5/20/2014	13.2	7.41	590	289	6.3	NA	NA
7102101	5/20/2014	13.2	7.41	590	289	6.3	NA	NA
7102901	5/20/2014	13.1	7.34	572	280	2.8	NA	NA
7103701	5/20/2014	14.4	7.35	575	282	3.9	NA	NA
7104401	5/20/2014	15.4	7.24	771	378	7.6	NA	NA
7105101	5/20/2014	14.0	7.25	636	312	8.6	NA	NA
7100201	5/21/2014	14.0	7.19	1382	678	**50**	NA	NA
7100401	5/21/2014	16.8	7.5	496	243	0.29	NA	NA
7103601	5/21/2014	11.7	7.45	865	424	1.8	NA	NA
7104601	5/21/2014	13.9	6.95	669	328	7.1	NA	NA
8601101	5/22/2014	14.7	7.25	2828	1388	6.8	<0.10	NA
3100201	5/22/2014	20.9	7.54	2154	1055	0.43	5.9	NA
3100401	5/22/2014	21.0	7.69	1995	978	<0.050	7.2	NA
3100601	5/22/2014	21.6	7.5	2257	1110	1.1	6	NA
3101101	5/22/2014	19.4	7.45	2650	1301	1.6	7.1	NA
3101601	5/22/2014	20.0	7.71	2361	1158	0.37	8.3	NA
8600801	5/27/2014	16.3	7.54	996	488	<0.050	2.7	NA
8601401	5/27/2014	15.3	7.18	1374	673	7.8	<0.10	NA
8601801	5/27/2014	16.3	7.87	948	465	<0.050	4.9	NA
8602001	5/27/2014	14.4	6.98	2506	1227	**12**	<0.10	NA
8603001	5/27/2014	22.3	7.24	1369	671	<0.050	8.4	NA
8650101	5/28/2014	15.1	7.4	965	473	**13**	<0.10	NA
8650301	5/28/2014	15.3	6.95	2512	1230	**110**	<0.10	NA
8650601	5/28/2014	13.7	7.38	1177	577	4.3	<0.10	NA
8651301	5/28/2014	17.4	7.6	559	274	1.1	<0.10	NA
8656501	5/28/2014	15.1	7.24	621	304	2.4	<0.10	NA
8650201	5/29/2014	15.9	7.46	821	402	7.1	<0.10	NA
8650501	5/29/2014	17.0	6.96	2019	989	**18**	<0.10	NA
8650701	5/29/2014	15.7	7.32	1208	592	**28**	<0.10	NA
8653401	5/29/2014	13.4	7.25	898	440	2.9	<0.10	NA
8100401	6/2/2014	14.2	7.32	1162	569	**14**	NA	NA
8100601	6/2/2014	13.4	7.4	1175	575	**21**	NA	NA
8101601	6/2/2014	12.7	6.8	320	157	4.1	NA	NA
8102101	6/2/2014	14.9	7.18	498	244	5.9	NA	NA

ISDA Well ID	Sample Date	Temperature (°C)	pH	Specific Conductivity	TDS	Nitrate	Ammonia	$\delta^{15}N$ (‰)
8102601	6/2/2014	11.7	6.93	1143	560	9.5	NA	NA
3004601	6/16/2014	17.2	7.45	985	484	**15**	NA	NA
8900401	6/16/2014	18.0	7.1	993	487	8.0	NA	NA
8900501	6/16/2014	17.4	7.27	777	381	3.8	NA	NA
8900601	6/16/2014	16.1	7.26	744	365	2.8	NA	NA
8900801	6/16/2014	15.9	7.22	1616	792	**46**	NA	NA
8901301	6/16/2014	24.1	8.51	510	250	<0.050	NA	NA
8700501	6/18/2014	12.2	7.52	804	395	**13**	NA	NA
8700601	6/18/2014	15.4	7.54	450	221	1.9	NA	NA
8700801	6/18/2014	13.4	7.46	878	430	7.7	NA	NA
8701201	6/18/2014	14.7	7.55	915	448	**10**	NA	NA
8701401	6/18/2014	14.1	7.3	872	427	6.4	NA	NA
8901801	6/18/2014	16.7	7.3	1042	510	**12**	NA	NA
7504701	6/19/2014	15.0	7.32	653	320	2.0	NA	NA
7504801	6/19/2014	15.1	7.31	636	311	2.8	NA	NA
7504901	6/19/2014	15.2	7.26	605	297	1.6	NA	NA
7505601	6/19/2014	15.4	7.2	591	290	2.7	NA	NA
7505801	6/19/2014	15.3	7.1	602	295	2.9	NA	NA
8700401	6/19/2014	15.8	7.65	516	253	1.8	NA	NA
7502201	6/23/2014	14.6	7.72	408	200	1.1	NA	NA
7502401	6/23/2014	15.4	7.5	633	310	3.5	NA	NA
7502601	6/23/2014	15.6	7.55	530	261	2.3	NA	NA
7503401	6/23/2014	15.7	7.82	340	167	0.71	NA	NA
7507001	6/23/2014	14.4	7.32	1054	517	**11**	NA	NA
7507401	6/23/2014	16.1	7.43	607	297	3.4	NA	NA
7501401	6/24/2014	14.8	7.53	644	315	4.1	NA	NA
7503001	6/24/2014	15.4	7.54	603	296	3.2	NA	NA
7506601	6/24/2014	15.6	7.58	569	279	8.2	NA	NA
8404301	6/24/2014	13.5	7.42	366	180	0.81	NA	NA
8405001	6/24/2014	12.2	7.42	420	206	1.8	NA	NA
8406101	6/24/2014	13.0	7.27	467	229	2.0	NA	NA
8300201	6/25/2014	12.9	7.81	284	139	3.8	NA	NA
8300301	6/25/2014	12.8	7.74	303	150	4.7	NA	NA
8300401	6/25/2014	13.1	7.79	279.8	137	3.5	NA	NA
8300501	6/25/2014	13.8	7.77	326	160	4.9	NA	NA
8303001	6/25/2014	11.7	7.5	696	341	8.8	NA	NA
8405801	6/25/2014	11.8	7.35	447	218	1.1	NA	NA
3200101	6/26/2014	8.9	7.29	474	232	8.5	NA	NA
3201001	6/26/2014	11.4	7.58	475	232	**10**	NA	NA

ISDA Well ID	Sample Date	Temperature (°C)	pH	Specific Conductivity	TDS	Nitrate	Ammonia	$\delta^{15}N$ (‰)
8050301	6/26/2014	10.7	7.36	467	229	2.2	NA	NA
8053401	6/26/2014	10.1	7.47	321	157	1.3	NA	NA
8053501	6/26/2014	8.6	7.16	495	243	**11**	NA	NA
8054601	6/26/2014	11.0	7.23	724	359	**26**	NA	NA
3300401	7/1/2014	21.4	7.92	219	108	1.3	NA	NA
3300501	7/1/2014	15.2	8.06	285	140	<0.050	NA	NA
7804301	7/7/2014	13.5	7.51	809	396	6.8	NA	NA
7804401	7/7/2014	15.8	7.28	791	388	3.1	NA	NA
7803601	7/8/2014	13.4	7.62	1070	526	9.1	NA	NA
7803701	7/8/2014	13.3	7.54	812	398	5.4	NA	NA
7805501	7/8/2014	15.0	7.46	866	424	8.5	NA	NA
7805601	7/8/2014	14.3	7.47	782	383	6	NA	NA
7805701	7/8/2014	13.9	7.51	855	419	9.7	NA	NA
7806401	7/8/2014	14.9	7.4	682	335	4.1	NA	NA
7806601	7/8/2014	12.3	7.42	745	365	4.7	NA	NA
7300801	7/9/2014	12.8	7.23	942	462	**10**	NA	NA
7303201	7/9/2014	13.9	7.04	2799	1372	**46**	NA	NA
7304501	7/9/2014	13.3	7.18	823	404	**10**	NA	NA
7800201	7/9/2014	14.2	7.27	738	362	5.0	NA	NA
7801701	7/9/2014	15.0	7.52	808	396	8.2	NA	NA
7804201	7/9/2014	13.3	7.33	731	358	6.4	NA	NA
7300201	7/10/2014	13.6	7.3	755	370	8.9	NA	NA
7300501	7/10/2014	16.6	7.51	513	251	2.3	NA	NA
7300901	7/10/2014	13.6	7.35	904	443	8.8	NA	NA
7301101	7/10/2014	15.3	7.35	540	265	5.6	NA	NA
7301601	7/10/2014	12.8	7.28	757	371	9.4	NA	NA
7302001	7/10/2014	17.4	7.35	511	251	4.1	NA	NA
7301801	7/16/2014	15.1	7.51	700	343	6.6	NA	3.3
7304101	7/16/2014	14.7	7.52	612	302	**12**	NA	3.6
7303101	7/16/2014	15.0	7.53	588	288	5.1	NA	4.5
7303901	7/16/2014	16.1	7.42	544	267	6.1	NA	5.1
7301901	7/16/2014	15.2	7.36	846	415	**13**	NA	10.9
7301501	7/16/2014	15.0	7.8	534	262	<0.050	NA	NA
7303001	7/16/2014	15.4	7.52	517	254	3.5	NA	NA
7303401	7/16/2014	13.0	7.56	540	265	0.11	NA	NA
7304301	7/16/2014	15.6	7.32	585	287	4.2	NA	NA
7401801	7/17/2014	15.4	7.42	706	346	5.6	NA	4.3
7405101	7/17/2014	14.6	7.52	633	310	5.7	NA	4.6
7404801	7/17/2014	14.0	7.3	758	327	8.8	NA	5.4

ISDA Well ID	Sample Date	Temperature (^oC)	pH	Specific Conductivity	TDS	Nitrate	Ammonia	$\delta^{15}N$ (‰)
7400401	7/17/2014	13.4	7.55	471	231	2.2	NA	NA
7402001	7/17/2014	14.1	7.48	820	402	6.3	NA	NA
7403201	7/17/2014	14.7	7.39	727	357	4.9	NA	NA
7404901	7/17/2014	19.0	7.73	377	185	0.85	NA	NA
7901701	7/22/2014	13.0	7.46	573	281	6.7	NA	1.5
7903601	7/22/2014	14.0	7.42	658	322	**11**	NA	7.1
7901401	7/22/2014	13.5	7.27	775	379	**17**	NA	9.1
7901601	7/23/2014	12.2	7.42	739	362	**12**	NA	3.7
7902001	7/23/2014	14.0	7.48	695	340	**11**	NA	4.7
7903201	7/23/2014	12.8	7.32	651	320	8.0	NA	5.4
7901901	7/23/2014	13.1	7.46	804	394	**13**	NA	5.8
7903501	7/23/2014	13.7	7.40	789	388	**14**	NA	5.9
7902201	7/23/2014	12.8	7.06	529	259	1.4	NA	NA
7901001	7/24/2014	14.9	7.53	701	343	**11**	NA	3.1
7901501	7/24/2014	14.3	7.40	761	372	8.9	NA	3.4
7904101	7/24/2014	12.8	7.28	547	268	5.6	NA	4.6
7900901	7/24/2014	13.9	7.42	571	280	5.3	NA	5.3
7900801	7/24/2014	14.4	7.45	672	329	**11**	NA	6.9
7901801	7/24/2014	14.1	7.52	475	233	2.5	NA	NA
7902101	7/29/2014	16.6	7.47	669	328	**13**	NA	4.5
7901101	7/29/2014	16.1	7.43	514	252	3.8	NA	NA
7904401	7/29/2014	14.6	7.42	464	228	3.3	NA	NA
7900101	7/30/2014	18.3	7.52	746	366	5.1	NA	5.3
7900601	7/30/2014	13.3	7.44	752	368	9.6	NA	5.6
7900701	7/30/2014	13.3	7.10	681	334	**13**	NA	6.6
7903701	7/30/2014	14.3	6.93	541	265	7.4	NA	7.1
7903801	7/30/2014	17.5	7.22	587	288	6.1	NA	9.2
7901301	7/30/2014	16.5	7.22	442	217	3.3	NA	NA
7904001	7/30/2014	14.5	7.3	542	265	4.5	NA	NA
8602001	8/13/2014	15.6	6.87	1607	788	6.5	0.5	6.2
8603001	8/13/2014	21.9	6.92	1290	632	<0.050	8.5	NA
8601401	8/13/2014	15.4	6.95	1280	627	7.7	<0.10	8.0
8601101	8/13/2014	14.5	7.28	1990	973	4.3	<0.10	NA
3100201	8/13/2014	19.9	7.25	1967	963	0.57	5.7	NA
9504301	9/8/2014	11.7	7.47	681	334	**20**	NA	3.4
9500201	9/8/2014	15.1	7.29	472	232	6.0	NA	5.6
9501401	9/8/2014	14.5	6.89	927	455	**37**	NA	13.2
9502801	9/8/2014	13.7	7.54	358	175	0.16	NA	NA
9503601	9/9/2014	11.4	7.04	350	171	**10**	NA	13.0

ISDA Well ID	Sample Date	Temperature (^{o}C)	pH	Specific Conductivity	TDS	Nitrate	Ammonia	$\delta^{15}N$ (‰)
9501201	9/9/2014	12.1	7.34	270.3	132	2.3	NA	NA
9504501	9/9/2014	10.3	7.16	224.8	110	2.8	NA	NA
9505701	9/9/2014	10.8	7.37	258.5	127	2.5	NA	NA
9505401	9/10/2014	12.4	7.46	493	242	**14**	NA	2.6
9507001	9/10/2014	12.4	7.14	641	315	**18**	NA	5.5
9501901	9/10/2014	15.3	7.33	399	195	4.0	NA	NA
3300501	9/10/2014	15.5	7.78	264.5	130	<0.050	NA	NA
9502201	10/7/2014	12.8	7.52	380	188	9.8	NA	4.9
9505501	10/7/2014	18.4	7.77	254.6	125	<0.050	NA	NA
3003001	10/8/2014	13.4	7.39	262.5	129	<0.050	NA	NA
3003701	10/8/2014	11.5	7.36	171.6	84	2.1	NA	NA
3003601	10/8/2014	16.4	6.79	165.2	81	8.3	NA	NA
8201201	10/9/2014	10.0	7.58	233	114	1.9	NA	NA
8204701	10/9/2014	9.6	7.58	286	140	1.1	NA	NA
8205001	10/9/2014	13.2	7.68	264.9	129	2.0	NA	NA
8205101	10/9/2014	8.6	7.56	309	152	2.6	NA	NA
8205201	10/9/2014	11.8	7.78	243.6	119	1.8	NA	NA
8204801	10/9/2014	9.6	7.77	255.5	125	0.65	NA	NA

Notes: Bolded red numbers indicate EPA's National Primary Drinking Water Regulation standard, expressed as a maximum contaminant level (MCL), was reached or exceeded. Italicized red numbers indicate EPA's National Secondary Drinking Water Regulation standard was exceeded. These regulations are applicable for public water systems only and are used with private wells to evaluate water quality.
Not analyzed (NA).

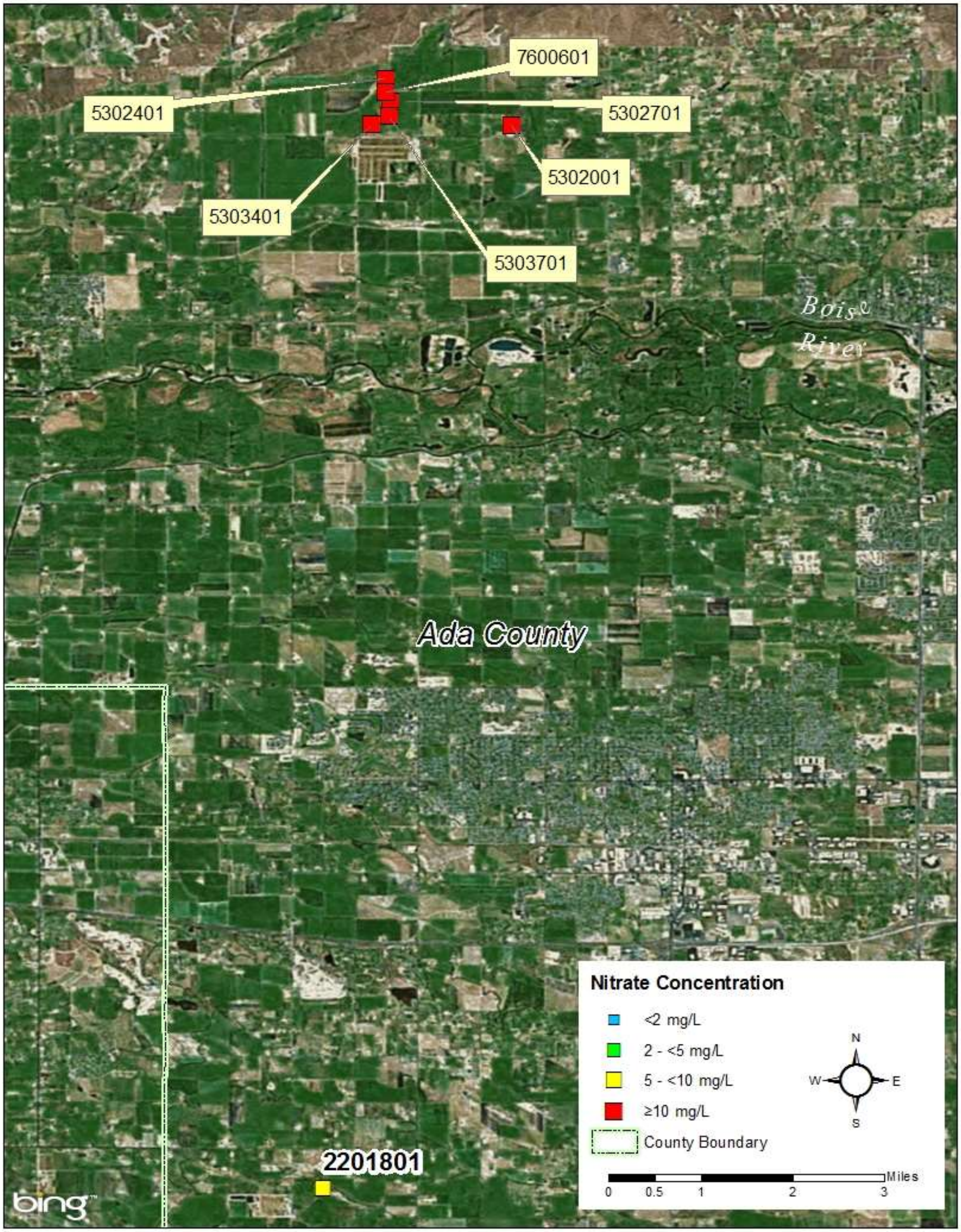


Figure A1. Ada County nitrate concentrations—ISDA 2014 data.

Figure A2. Canyon and Owyhee Counties nitrate concentrations—ISDA 2014 data.

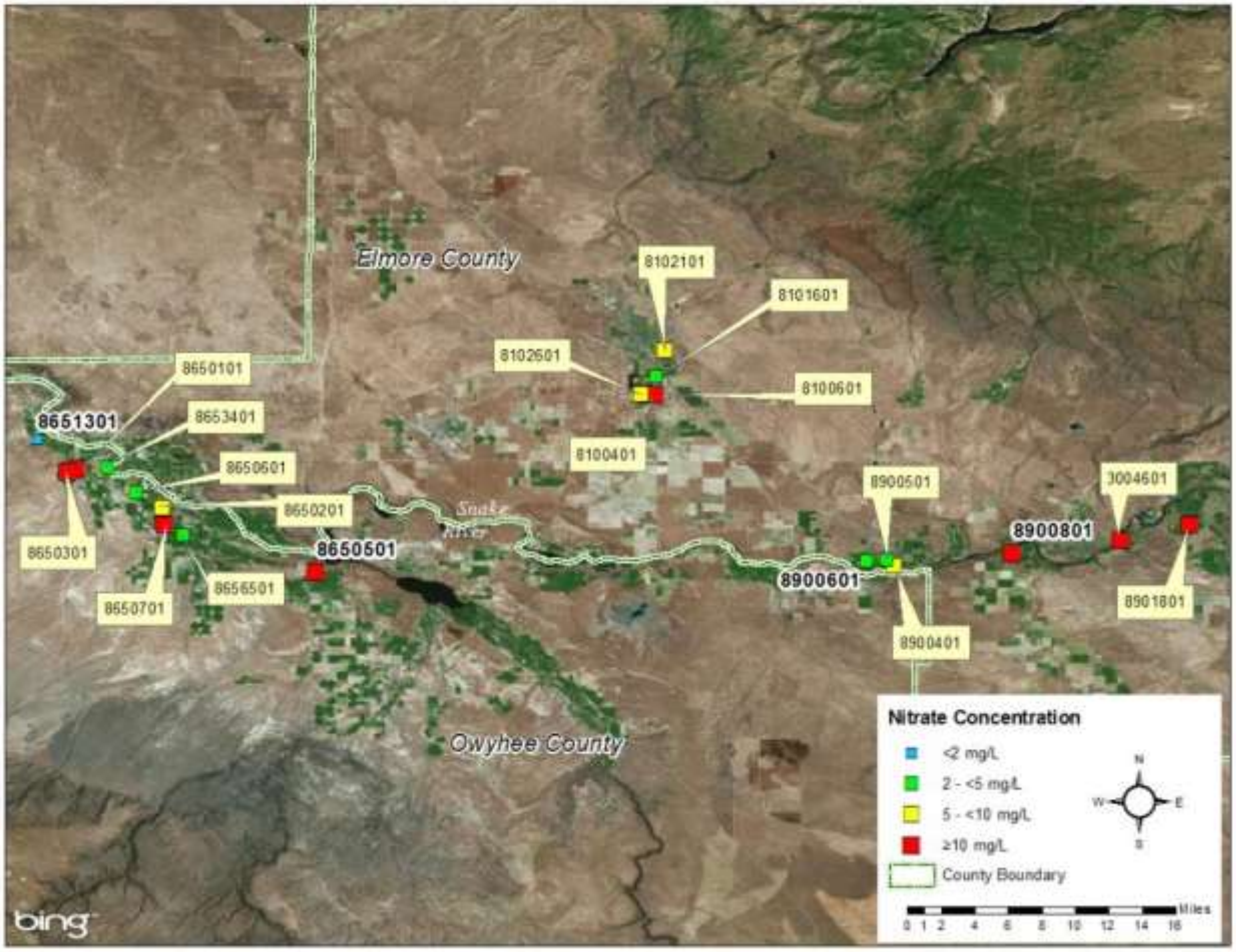


Figure A3. Eastern Owyhee County and Elmore County nitrate concentrations—ISDA 2014 data.

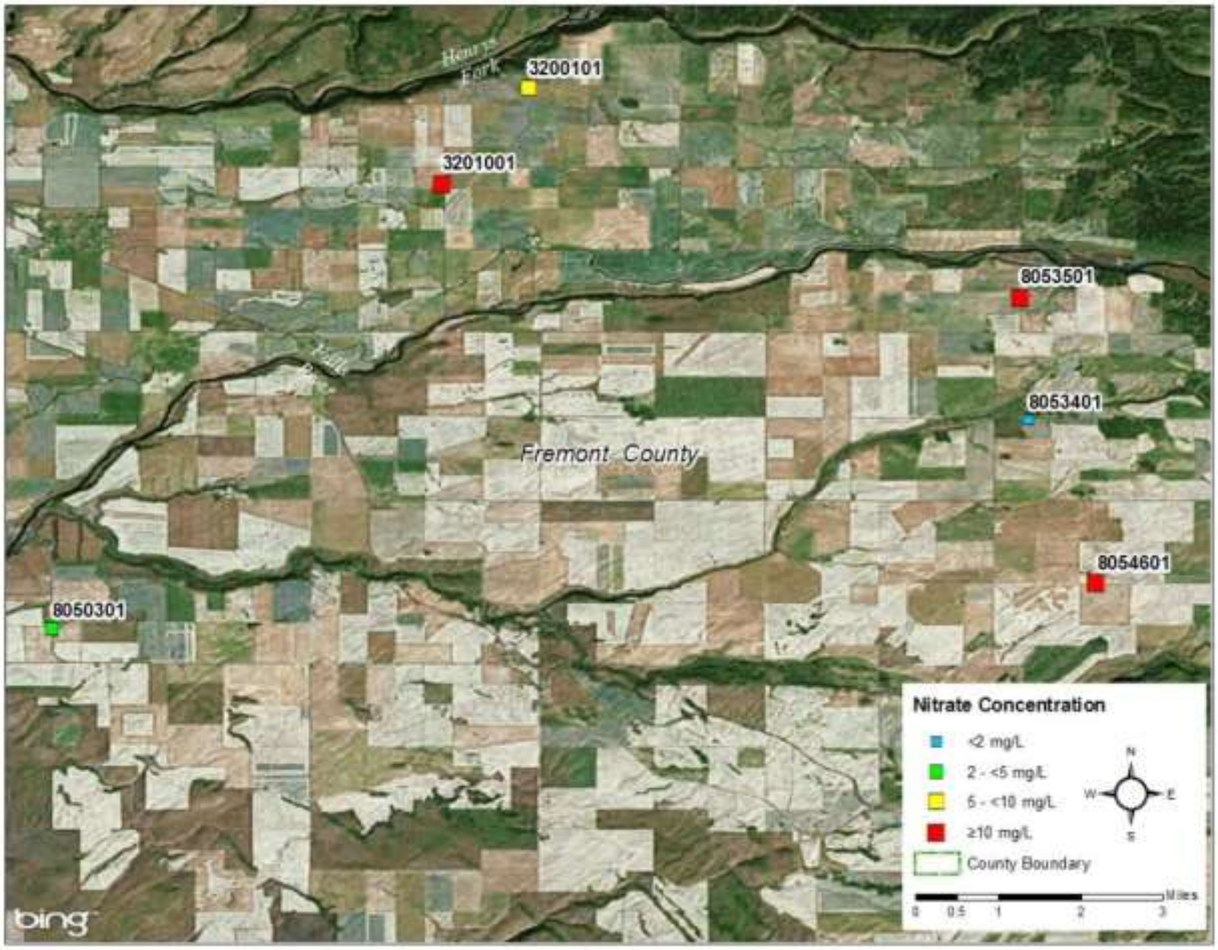


Figure A4. Fremont County nitrate concentrations—ISDA 2014 data.

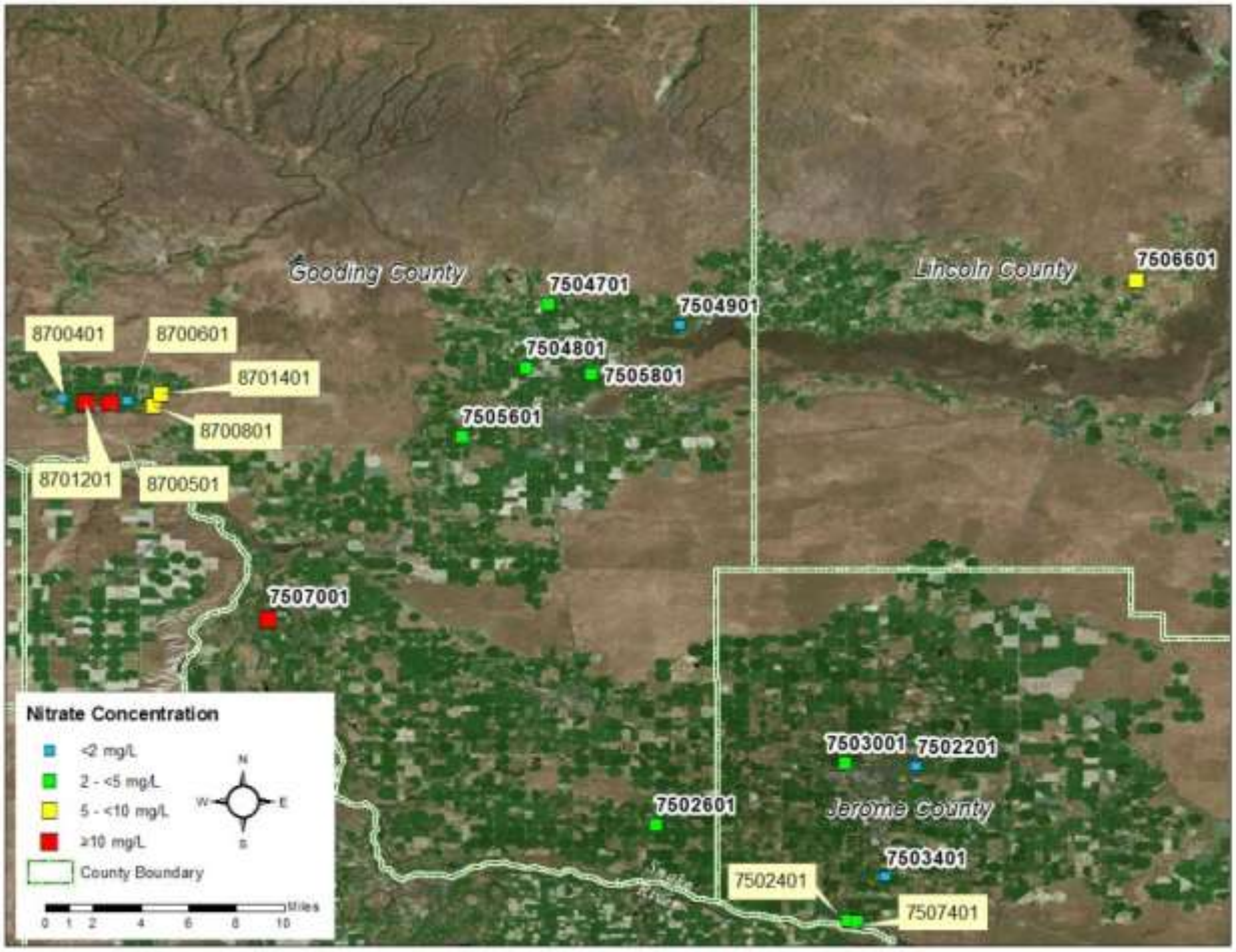


Figure A5. Gooding, Jerome, and Lincoln Counties nitrate concentrations—ISDA 2014 data.

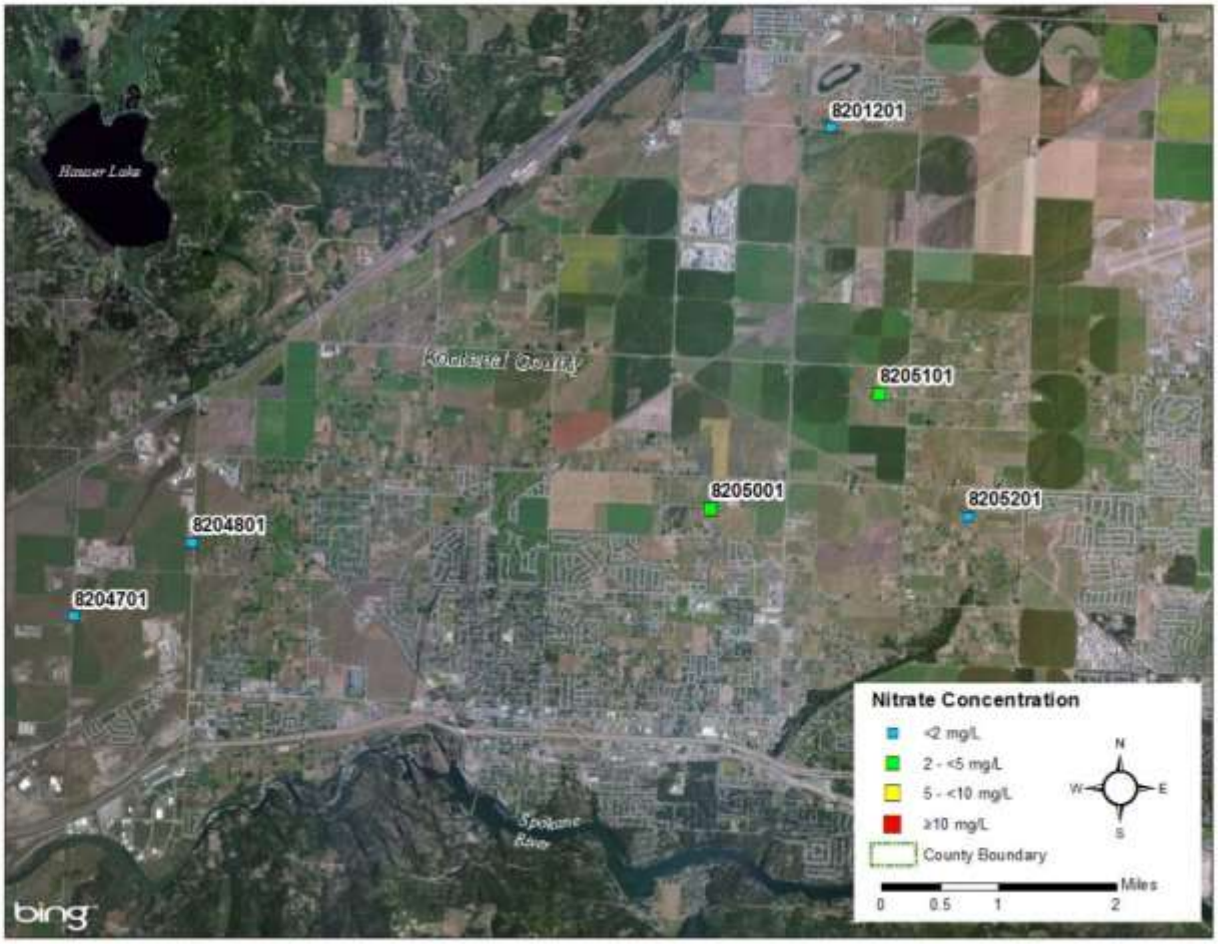


Figure A6. Kootenai County nitrate concentrations—ISDA 2014 data.

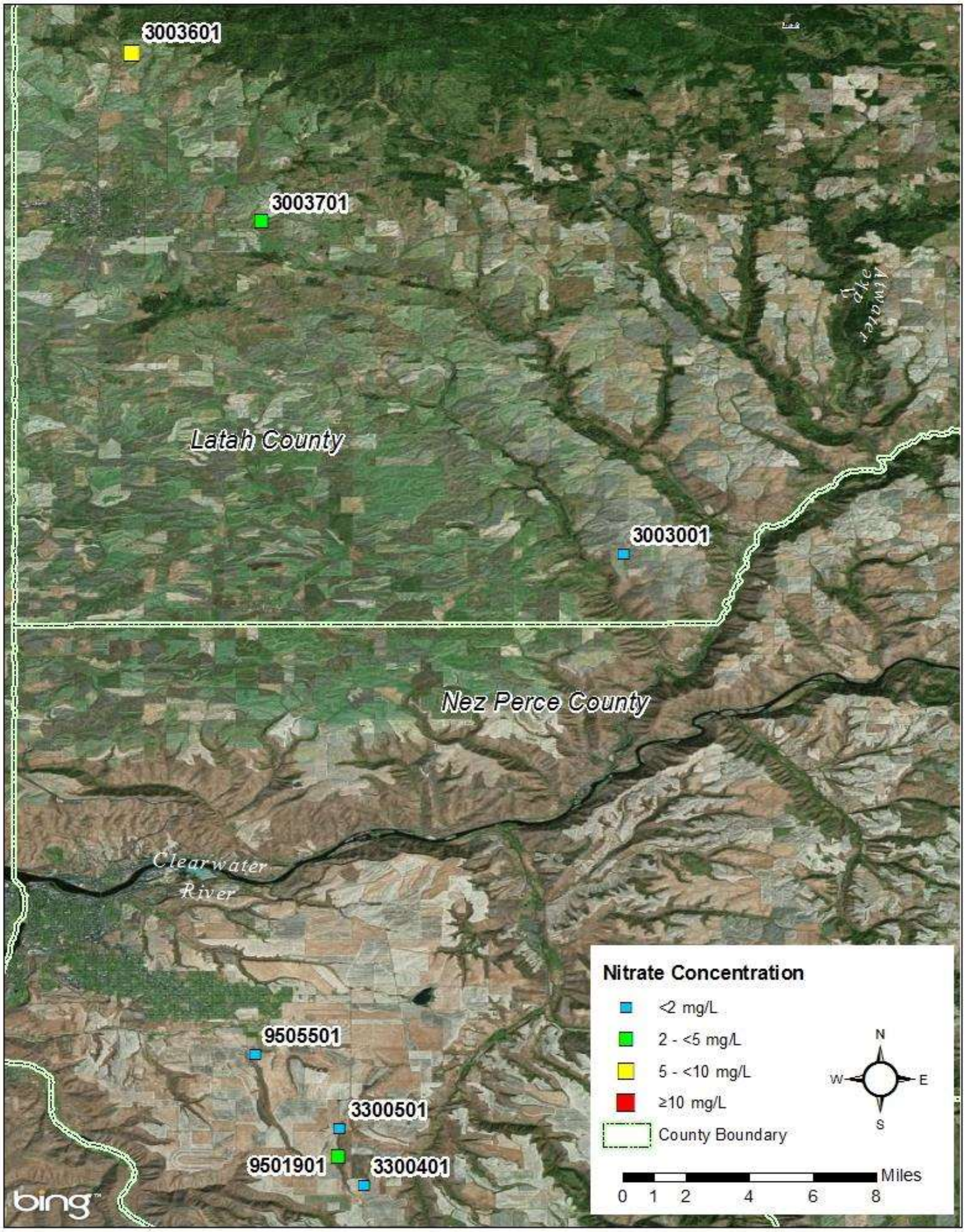


Figure A7. Latah and Nez Perce Counties nitrate concentrations—ISDA 2014 data.

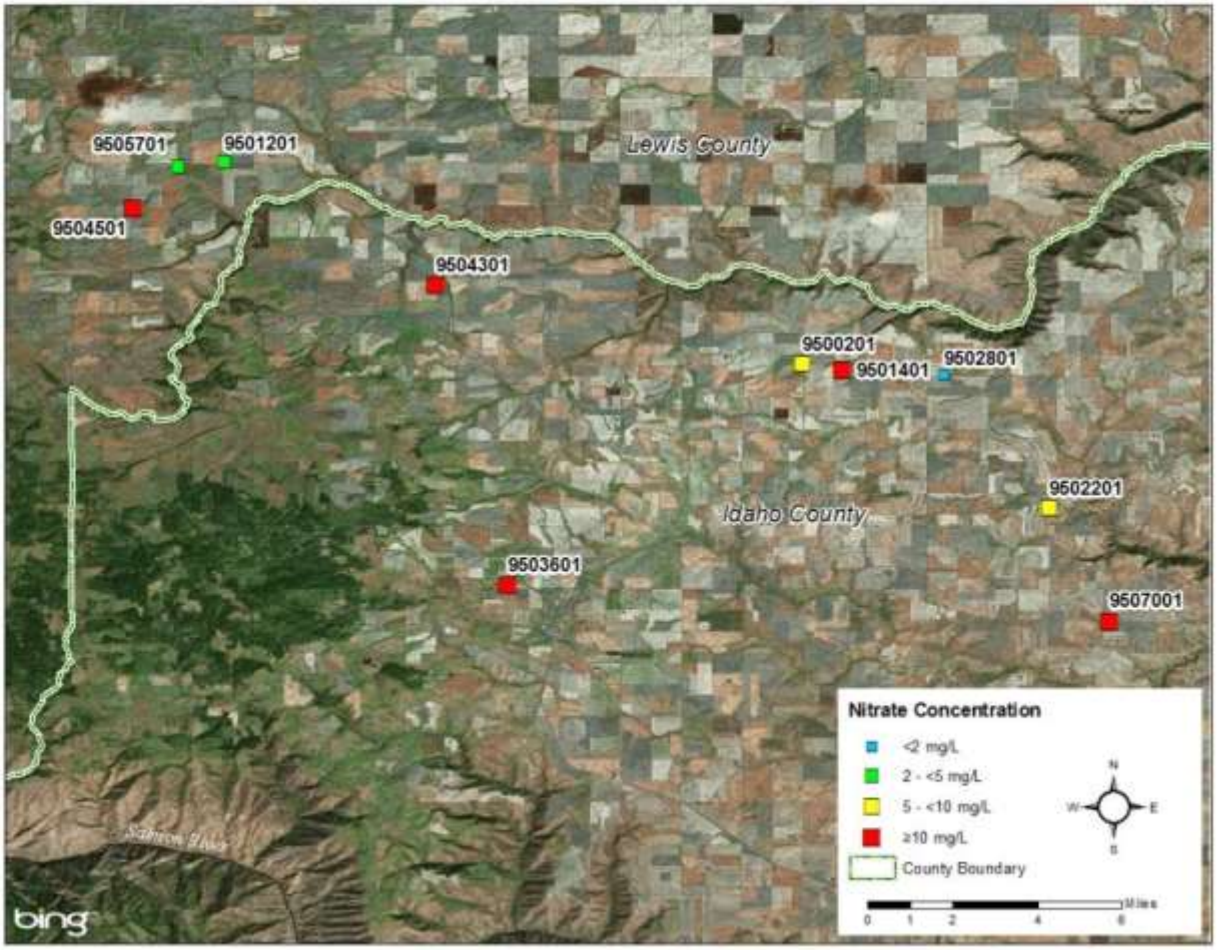
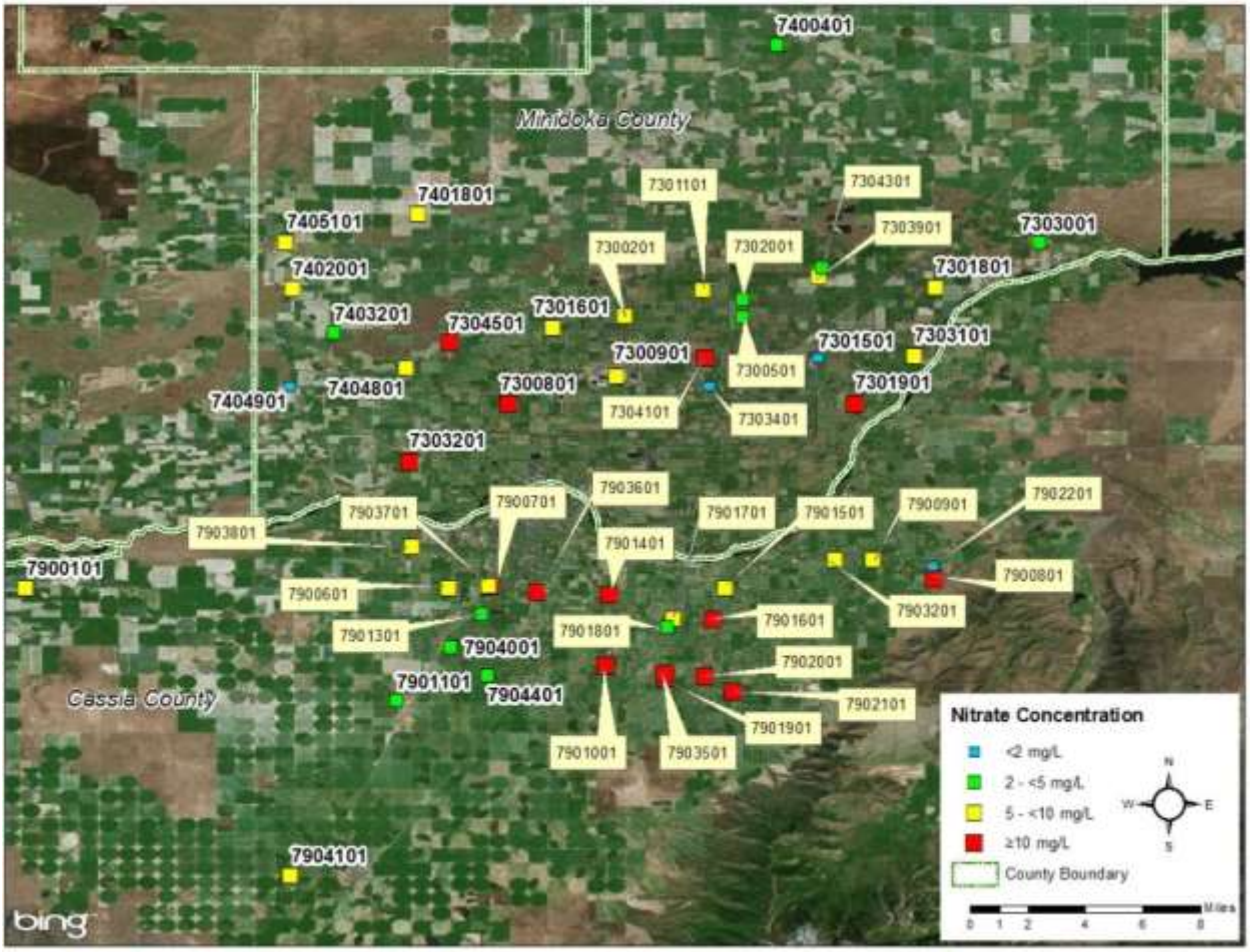


Figure A8. Lewis and Idaho Counties nitrate concentrations—ISDA 2014 data.



FigureA9. Minidoka and Cassia Counties nitrate concentrations—ISDA 2014 data.

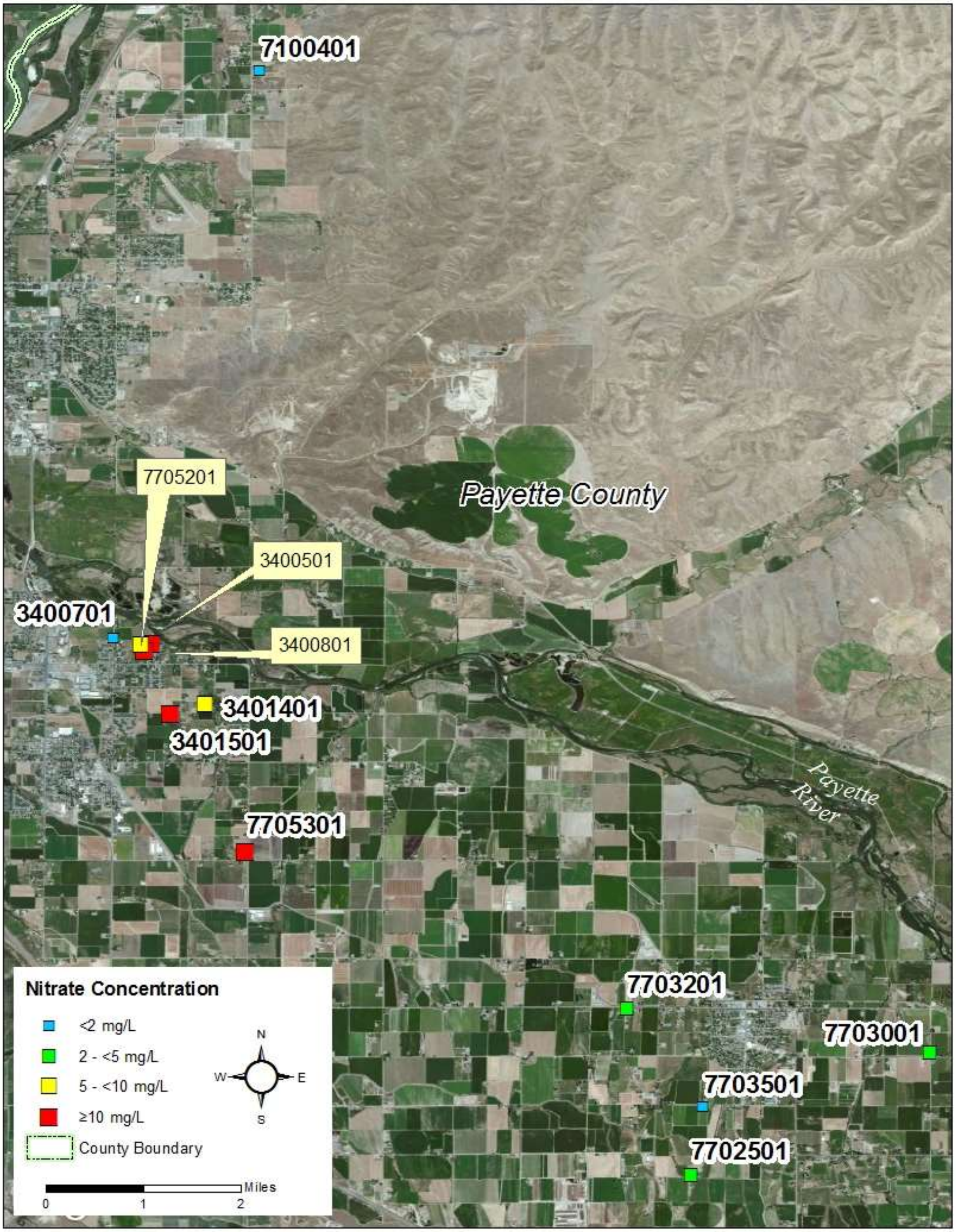


Figure A10. Payette County nitrate concentrations—ISDA 2014 data.

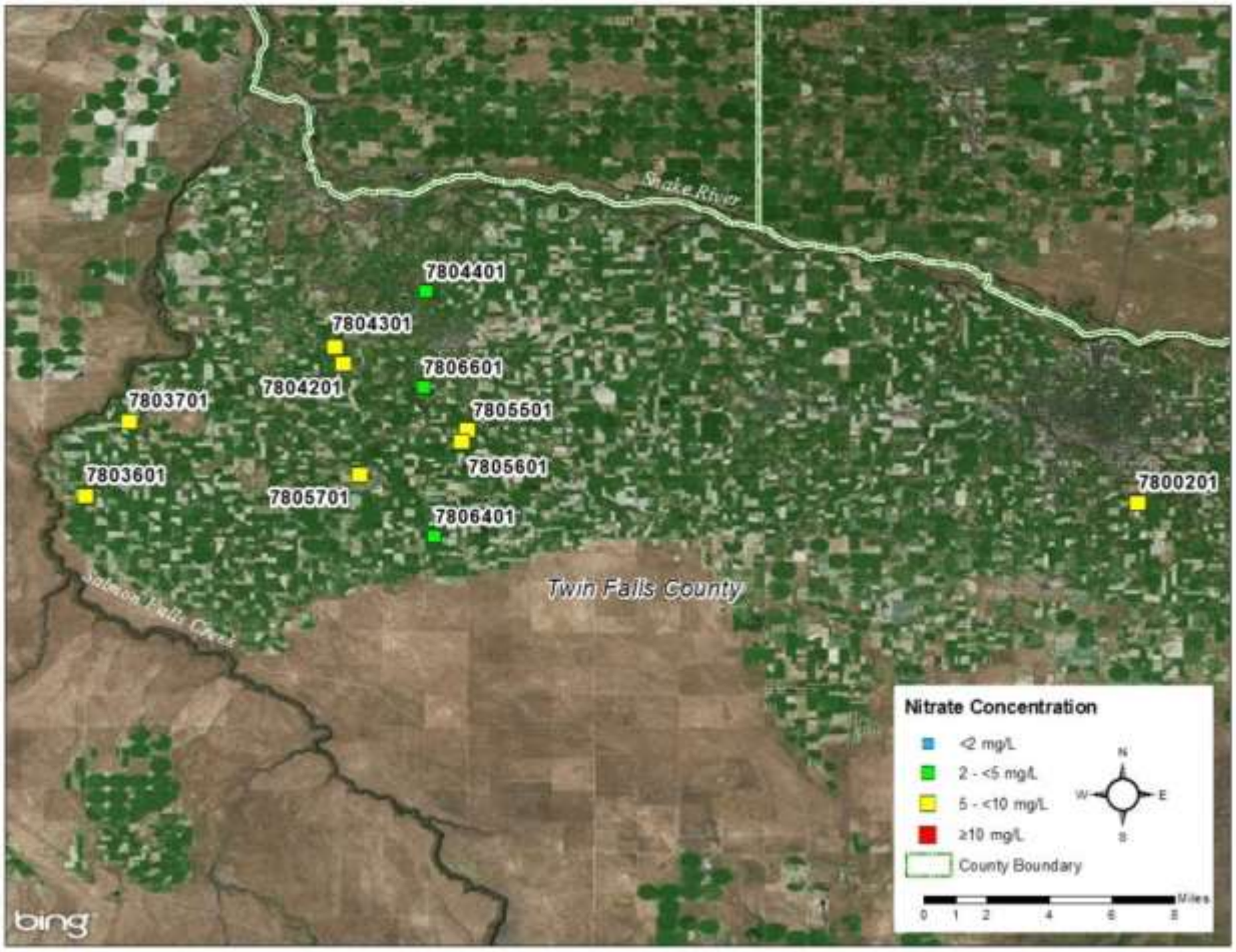


Figure A11. Twin Falls County nitrate concentrations—ISDA 2014 data.

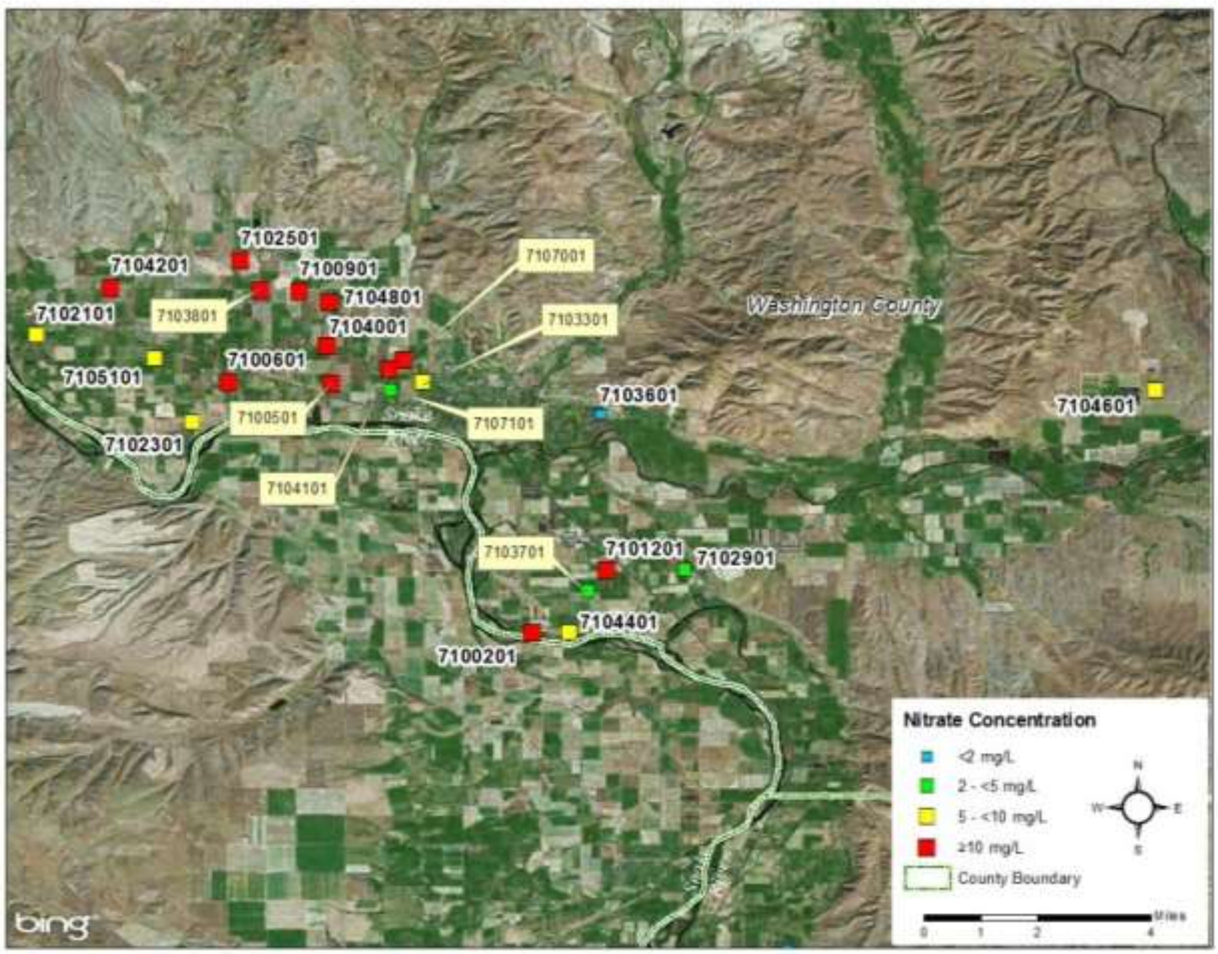


Figure A12. Washington County nitrate concentrations—ISDA 2014 data.

Appendix B. Idaho Department of Water Resources (IDWR) 2014 data.

Table B1. Sulfamethoxazole results—IDWR 2014 data.

Well ID (IDWR)	Sulfamethoxazole (mg/L)	Sample Date and Time
01N 04E 32AAB1	<0.025	7/7/14 1:47 PM
02N 03E 28CAC1	<0.025	7/8/14 11:28 AM
03N 04E 21CAC1	<0.025	7/9/14 10:20 AM
03N 01E 14BBD1	<0.025	7/9/14 2:12 PM
02N 01W 02BBA1	<0.025	7/10/14 2:53 PM
02N 01W 11ADA1	<0.025	7/10/14 3:30 PM
03N 01E 25BCB1	<0.025	7/10/14 4:50 PM
05N 01W 09CCD2	<0.025	7/11/14 9:30 AM
05N 01E 30CAC1	<0.025	7/11/14 10:43 AM
04N 01W 01CAA1	<0.025	7/11/14 12:02 PM
04N 01W 12DDB1	<0.025	7/11/14 2:11 PM
04N 01E 06BBB1	<0.025	7/11/14 3:27 PM
02N 03E 10BBB1	<0.025	7/14/14 8:51 AM
05N 02E 30DAD1	<0.025	7/14/14 1:26 PM
04N 01W 21DDA1	<0.025	7/14/14 3:10 PM
04N 01W 02AAB1	<0.025	7/15/14 8:59 AM
04N 01E 11BBB1	<0.025	7/15/14 11:02 AM
02N 02E 04CBB1	<0.025	7/15/14 12:50 PM
01S 04E 17CCC2	<0.025	7/15/14 2:00 PM
04N 01E 13BDDB1	<0.025	8/14/14 11:17 AM
02N 01E 31DDC1	<0.025	8/18/14 10:21 AM
19N 01E 24BCA1	<0.025	7/30/14 1:05 PM
15N 01W 10BBB1	<0.025	7/30/14 4:15 PM
19N 02E 29ADB1	<0.025	8/2/14 1:58 PM
17N 01W 02DDA1	<0.025	8/2/14 3:10 PM
15N 01W 16DAD1	<0.025	8/2/14 4:32 PM
08S 36E 15CDC1	<0.025	7/29/14 1:00 PM
05S 33E 36ADA1	<0.025	7/29/14 2:05 PM
12S 37E 08ABA1	<0.025	7/29/14 2:35 PM
09S 36E 22CCC1	<0.025	7/29/14 3:35 PM
09S 38E 28CAC2	<0.025	7/29/14 5:20 PM
12S 36E 01BCD1	<0.025	7/30/14 9:15 AM
10S 37E 17BDB1	<0.025	7/30/14 10:40 AM
05S 34E 05DADD1	<0.025	7/30/14 12:50 PM
06S 34E 07ADA2	<0.025	7/30/14 3:05 PM
07S 35E 18AAC1	<0.025	7/30/14 4:25 PM

Well ID (IDWR)	Sulfamethoxazole (mg/L)	Sample Date and Time
13S 38E 10BCA1	<0.025	8/7/14 9:52 AM
10S 40E 12AAB1	<0.025	8/5/14 12:00 AM
13S 44E 15DAD1	<0.025	8/5/14 4:24 PM
14S 44E 12ACA1	<0.025	8/5/14 5:40 PM
46N 02W 16BBD1	<0.025	7/21/14 3:54 PM
44N 01W 28DAB1	<0.025	7/22/14 10:24 AM
43N 01E 08CCC1	<0.025	7/22/14 12:45 PM
45N 01W 29BAD1	<0.025	7/22/14 2:00 PM
46N 05W 20BBD1	<0.025	7/22/14 4:20 PM
02S 33E 18AAD1	<0.025	9/10/14 12:00 AM
02S 35E 28BCDA2	<0.025	9/10/14 12:00 AM
04S 30E 36BCA1	<0.025	9/10/14 10:40 AM
01N 37E 21CBC1	<0.025	9/10/14 12:00 PM
04S 34E 26DAD1	<0.025	9/29/14 12:00 PM
04S 34E 21CBB2	<0.025	9/29/14 2:00 PM
03N 18E 18AAA1	<0.025	8/6/14 8:37 AM
01S 18E 31DBC1	<0.025	8/6/14 12:05 PM
01S 21E 23BCB1	<0.025	8/6/14 2:37 PM
01S 21E 22BCC1	<0.025	8/6/14 3:30 PM
09N 04E 26BDB1	<0.025	7/24/14 11:31 AM
09N 04E 15CCA1	<0.025	7/24/14 12:50 PM
54N 03W 24BBB1	<0.025	7/23/14 11:11 AM
55N 05W 18DBD1	<0.025	7/24/14 10:54 AM
56N 04W 30BAD1	<0.025	7/24/14 12:43 PM
55N 04W 28DBB1	<0.025	7/24/14 2:02 PM
55N 06W 01DDD1	<0.025	7/25/14 12:20 PM
56N 04W 06BDD1	<0.025	7/28/14 9:38 AM
59N 01W 09BCC1	<0.025	7/28/14 11:55 AM
59N 01E 32CAC1	<0.025	7/28/14 12:57 PM
57N 01E 21BAB1	<0.025	7/30/14 9:31 AM
56N 02E 27DDB1	<0.025	7/30/14 10:35 AM
01N 39E 36AAC1	<0.025	9/9/14 11:00 AM
01S 40E 28CDC1	<0.025	9/9/14 12:45 PM
01S 45E 19BBB1	<0.025	9/9/14 3:20 PM
02N 37E 21CDD1	<0.025	9/11/14 9:30 AM
03N 40E 02AAC1	<0.025	9/16/14 12:00 AM
02N 38E 18CBC1	<0.025	10/9/14 10:00 AM
64N 01W 08AAB1	<0.025	7/29/14 9:51 AM
65N 01W 26AAD1	<0.025	7/29/14 10:57 AM
65N 02E 30CCA1	<0.025	7/29/14 12:27 PM

Well ID (IDWR)	Sulfamethoxazole (mg/L)	Sample Date and Time
61N 01E 06AAB1	<0.025	7/29/14 1:50 PM
06N 25E 36DBB2	<0.025	8/7/14 4:14 PM
09N 27E 09DAA1	<0.025	8/8/14 11:21 AM
01S 15E 19BCB2	<0.025	8/5/14 3:15 PM
01N 02W 06ADD1	<0.025	7/16/14 8:34 AM
01N 03W 01DDD1	<0.025	7/16/14 9:45 AM
01S 02W 03DBC1	<0.025	7/16/14 10:40 AM
02N 02W 05ABA1	<0.025	7/16/14 12:45 PM
03N 02W 33CAD2	<0.025	7/16/14 1:45 PM
02N 02W 22CCA1	<0.025	7/16/14 3:07 PM
02N 02W 30BBA1	<0.025	7/16/14 3:53 PM
01N 02W 36CAA1	<0.025	7/17/14 9:30 AM
02N 03W 09ADA1	<0.025	7/17/14 11:33 AM
02N 02W 31CBA1	<0.025	7/17/14 12:05 PM
03N 02W 17CCB2	<0.025	7/17/14 2:00 PM
02N 03W 13CCA3	<0.025	7/21/14 12:00 AM
03N 02W 17BCB1	<0.025	7/21/14 11:10 AM
03N 03W 22AAA1	<0.025	7/21/14 12:30 PM
03N 04W 03AAD1	<0.025	7/21/14 3:25 PM
04N 03W 09BBD3	<0.025	7/22/14 9:26 AM
04N 03W 13BAA1	<0.025	7/22/14 10:55 AM
04N 02W 22DCD1	<0.025	7/22/14 12:15 PM
03N 05W 11DAD1	<0.025	7/22/14 2:16 PM
04N 02W 12CBC1	<0.025	7/22/14 4:02 PM
05N 02W 25BCD1	<0.025	7/23/14 9:03 AM
05N 05W 04DCD1	<0.025	7/23/14 10:00 AM
05N 05W 20CCD1	<0.025	7/23/14 11:55 AM
05N 06W 35CDB1	<0.025	7/23/14 1:48 PM
04N 04W 15DBB1	<0.025	7/23/14 3:10 PM
04N 04W 33CDC3	<0.025	7/24/14 11:10 AM
04N 05W 07DCA1	<0.025	7/24/14 1:23 PM
04N 03W 36BAC1	<0.025	7/24/14 3:05 PM
05N 03W 08DDC1	<0.025	7/28/14 11:55 AM
03N 01W 31DDA2	<0.025	8/7/14 9:55 AM
04N 02W 30ADA1	<0.025	8/7/14 2:30 PM
04N 04W 28ACB2	<0.025	8/20/14 10:35 AM
05S 43E 11BCB1	<0.025	8/5/14 10:24 AM
06S 42E 01DAC1	<0.025	8/5/14 11:26 AM
07S 42E 06CCC1	<0.025	8/5/14 12:34 PM
08S 41E 25BDA2	<0.025	8/5/14 2:54 PM

Well ID (IDWR)	Sulfamethoxazole (mg/L)	Sample Date and Time
15S 24E 22DCD1	<0.025	7/24/14 11:20 AM
14S 27E 17BBB1	<0.025	7/24/14 1:10 PM
09S 25E 19ADA1	<0.025	7/31/14 11:20 AM
09S 26E 20BBA1	<0.025	7/31/14 12:40 PM
11S 23E 11CDD1	<0.025	9/10/14 10:30 AM
10S 27E 04DDC1	<0.025	10/6/14 11:35 AM
10N 37E 01CAD1	<0.025	10/7/14 3:00 PM
40N 02E 26BDC1	<0.025	7/17/14 12:06 PM
35N 04E 35BBB1	<0.025	7/17/14 5:17 PM
07N 24E 28CDD1	<0.025	8/11/14 12:17 PM
07N 23E 02DDA1	<0.025	8/11/14 1:18 PM
13N 19E 12CCC1	<0.025	8/11/14 2:43 PM
14N 19E 28CAD1	<0.025	8/11/14 3:40 PM
07N 20E 33CDD1	<0.025	8/11/14 5:28 PM
10N 13E 35CBC1	<0.025	8/12/14 3:50 PM
10N 13E 09ADC1	<0.025	8/12/14 4:39 PM
03S 06E 27DDD1	<0.025	8/1/14 10:28 AM
04S 05E 21CAA1	<0.025	8/1/14 11:58 AM
05S 06E 32AAA1	<0.025	8/1/14 1:35 PM
01S 04E 23BBB1	<0.025	8/1/14 3:56 PM
05S 09E 13ACD1	<0.025	8/5/14 11:05 AM
05S 09E 27DBB1	0.41	8/5/14 1:00 PM
12S 40E 12CCB2	<0.025	8/6/14 10:42 AM
12S 40E 36AAD1	<0.025	8/6/14 11:37 AM
16S 40E 17BBB1	<0.025	8/6/14 12:43 PM
08N 41E 33ABB2	<0.025	10/1/14 11:15 AM
11N 43E 28CCA2	<0.025	10/9/14 12:00 PM
06N 03W 04DAD2	<0.025	7/23/14 11:12 AM
07N 03W 28CDD1	<0.025	7/23/14 12:13 PM
07N 01E 15DBD1	<0.025	7/23/14 2:15 PM
06N 01W 05CDD1	<0.025	8/7/14 11:08 AM
07N 01W 19DBA1	<0.025	8/7/14 12:40 PM
07N 01E 03CAA1	<0.025	8/13/14 9:02 AM
08S 15E 33ABB1	<0.025	8/6/14 10:45 AM
05S 15E 07DAA1	<0.025	8/6/14 12:45 PM
05S 13E 32CCC1	<0.025	8/6/14 2:10 PM
30N 03E 20AAC2	<0.025	7/14/14 11:45 AM
31N 03E 36BCA1	<0.025	7/14/14 1:00 PM
30N 01W 02AAA1	<0.025	7/14/14 4:37 PM
05N 34E 01ADBB1	<0.025	8/13/14 12:00 AM

Well ID (IDWR)	Sulfamethoxazole (mg/L)	Sample Date and Time
07N 36E 05CAA1	<0.025	8/13/14 11:30 AM
06N 35E 02BCC1	<0.025	8/13/14 2:00 PM
08N 34E 20AAD1	<0.025	8/15/14 10:00 AM
07S 17E 16ABA1	<0.025	7/17/14 9:20 AM
08S 20E 29CCC1	<0.025	7/17/14 11:10 AM
09S 16E 04ADC1	<0.025	8/22/14 1:15 PM
08S 17E 30CBD1	<0.025	10/14/14 2:45 PM
49N 04W 05BCB1	<0.025	7/21/14 8:58 AM
49N 04W 09CCC1	<0.025	7/21/14 10:10 AM
48N 05W 05DCC1	<0.025	7/21/14 11:18 AM
47N 03W 12BBA1	<0.025	7/21/14 1:37 PM
51N 05W 19DBC3	<0.025	7/23/14 8:58 AM
52N 04W 26AAA1	<0.025	7/23/14 10:07 AM
37N 03W 16CAA1	<0.025	7/15/14 9:08 AM
38N 05W 28CBD1	<0.025	7/16/14 9:40 AM
41N 04W 06BAC1	<0.025	7/16/14 12:20 PM
40N 01W 21BAC1	<0.025	7/16/14 2:13 PM
40N 05W 33DBC1	<0.025	7/16/14 4:42 PM
15N 22E 30BCBB1	<0.025	8/8/14 1:20 PM
20N 21E 01AAA1	<0.025	8/8/14 3:12 PM
19N 21E 14DBD1	<0.025	8/8/14 5:25 PM
15N 26E 14BDB1	<0.025	8/8/14 6:27 PM
34N 01W 34DAD1	<0.025	7/15/14 11:05 AM
34N 01E 25DDD1	<0.025	7/15/14 12:32 PM
33N 01W 09DCC1	<0.025	7/15/14 1:27 PM
34N 02E 34BDD1	<0.025	7/15/14 5:05 PM
05S 16E 25ABC1	<0.025	8/4/14 2:40 PM
04S 18E 12DDD1	<0.025	8/4/14 4:35 PM
05S 19E 31AAA1	<0.025	8/4/14 5:52 PM
06S 19E 11BDC1	<0.025	8/5/14 12:00 AM
04S 19E 34ABB3	<0.025	8/5/14 12:55 PM
06S 18E 03BAA1	<0.025	8/5/14 2:25 PM
06N 39E 05ABB1	<0.025	8/19/14 12:00 AM
06N 39E 20DCC1	<0.025	8/19/14 10:00 AM
05N 39E 12CBA1	<0.025	8/19/14 1:00 PM
06N 38E 35ABA1	<0.025	8/19/14 3:50 PM
06N 42E 10ADA1	<0.025	10/1/14 2:45 PM
10S 23E 05DCC1	<0.025	8/29/14 9:45 AM
09S 22E 36CDCC1	<0.025	8/29/14 10:45 AM
10S 23E 09CBCB1	0.46	8/29/14 11:50 AM

Well ID (IDWR)	Sulfamethoxazole (mg/L)	Sample Date and Time
37N 05W 35AAD1	<0.025	7/16/14 6:05 PM
35N 05W 02CCA1	<0.025	7/17/14 9:23 AM
16S 30E 09ABB2	<0.025	8/6/14 4:42 PM
16S 36E 14DBC1	<0.025	8/6/14 6:40 PM
13S 35E 27CCC1	<0.025	8/7/14 11:10 AM
02S 02W 10AAA1	<0.025	8/4/14 11:45 AM
06S 06E 30DBB1	<0.025	8/4/14 1:50 PM
02S 01W 06DDC1	<0.025	8/12/14 12:30 PM
06S 03E 01ABB1	<0.025	8/12/14 3:33 PM
06N 05W 09DCA1	<0.025	7/28/14 2:55 PM
08N 05W 08BAA1	<0.025	7/28/14 5:10 PM
09N 05W 13CCB1	<0.025	8/19/14 3:24 PM
06N 03W 30DCC1	<0.025	8/19/14 5:16 PM
06S 34E 07BBC2	<0.025	8/4/14 1:12 PM
07S 31E 01BDB1	<0.025	8/4/14 2:27 PM
06S 29E 32AAB1	<0.025	8/4/14 3:37 PM
07S 29E 28CAC1	<0.025	8/4/14 4:27 PM
11S 33E 02BAB1	<0.025	8/7/14 12:44 PM
45N 03E 04DCC1	<0.025	7/21/14 5:25 PM
42N 02E 07BAC1	<0.025	7/22/14 11:38 AM
03N 45E 05CAC1	<0.025	9/16/14 1:40 PM
05N 46E 19AAB1	<0.025	9/16/14 3:00 PM
10S 15E 08DDA1	<0.025	7/16/14 3:20 PM
11S 18E 23BBA1	<0.025	7/29/14 10:30 AM
12S 13E 26BCC1	<0.025	7/29/14 1:10 PM
11S 14E 09ABA1	<0.025	7/29/14 2:45 PM
10S 16E 15DDC1	<0.025	8/22/14 10:05 AM
10S 13E 14DAC1	<0.025	9/23/14 11:50 AM
09S 15E 30CAD1	<0.025	9/23/14 2:00 PM
14N 04E 32CCC1	<0.025	7/24/14 3:16 PM
16N 03E 14AAB1	<0.025	7/24/14 4:45 PM
11N 04W 34CBC1	<0.025	8/11/14 11:30 AM
10N 04W 07AAA1	<0.025	8/11/14 12:50 PM
10N 05W 09ACDD1	<0.025	8/11/14 1:52 PM
11N 06W 13DDA1	<0.025	8/13/14 11:30 AM
15N 02W 06CADD1	<0.025	8/13/14 2:12 PM
10N 05W 17ABBB1	<0.025	8/19/14 2:35 PM